COMBAT RATION ADVANCED MANUFACTURING TECHNOLOGY DEMONSTRATION (CRAMTD)

"Implementation of Sensors and Quality Control Strategies in the Integrated Manufacturing System"

Short Term Project (STP) #12

FINAL TECHNICAL REPORT
Results and Accomplishments (September 1992 through July 1995)
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DEFENSE LOGISTICS AGENCY
8725 John J. Kingman Road
Ft. Belvoir, VA 22060-6221

Contractor:
Rutgers, The State University of New Jersey
THE CENTER FOR ADVANCED FOOD TECHNOLOGY*
Cook College
N.J. Agricultural Experiment Station
New Brunswick, New Jersey 08903

Principal Investigator: Mr. Henderikus Bruins
Co-Principal Investigators: Drs. Elsayed A. Elsayed, Susan Albin,
Donald W. Schaffner and J.T. Luxhoj

Dr. John F. Coburn
Program Director

TEL: 908-445-6132
FAX: 908-445-6145

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Henderikus Bruins

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Rutgers, The State University of New Jersey
The Center for Advanced Food Technology
Cook College, NJ Agricultural Experiment Station
New Brunswick, NJ 08903

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To realize the advantages of Computer Integrated Manufacturing (CIM), faster and more effective inspection and control systems are required than can be provided manually. Inspection and control systems that use sensors, detectors and data entry stations to monitor conditions and detect variations in material flow, process parameters and product quality need to be considered, as well as controllers that are capable of determining real time corrective action. In this project, the configuration of the CRAMTD Demo plant and the architecture of information flow was laid out and a strategy was developed that could accommodate present and future management information needs. The MRE production line was selected to demonstrate the use of these advanced control strategies and seven areas of quality control were addressed. While a strategy was developed to support Level 2 and Level 3 CIM the implementation of sensors and quality control strategies was completed at Level 2 CIM. It is recommended that a follow-on project complete Level 3 CIM according to the SP-88 model.

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1.0 CRAMTD - STP#12
Results and Accomplishments

1.1 Introduction and Background

One of the objectives of the CRAMTD effort was to implement a Computer Integrated Manufacturing (CIM) System in a combat ration advanced manufacturing demonstration process. To realize the advantages of CIM, faster and more effective inspection and control systems in the manufacturing processes are required than can be provided manually. Inspection and control systems that use sensors, detectors and data entry stations to monitor conditions and detect variations in material flow, process parameters and product quality need to be considered, as well as controllers that are capable of determining real time corrective action. Some of the main benefits of integrated inspection and control are the ability of a producer to more efficiently track material flow through the process and obtain faster and more accurate data regarding the capability of the process. This should enable the producer to improve the overall quality of the product and lower the manufacturing cost by reducing the number of out of specification products.

The current project was a continuation of previous initiated STP's which addressed various components of a total integrated manufacturing system (STP#3, STP#4 and STP#5). This project worked closely together with two other projects which spanned the same time frame but focused on materials handling (STP#14) and the information flow (STP#16).

1.2 Results and Conclusions

To meet the stated objectives, the configuration of the plant and the architecture of information flow was laid out, and a strategy that could accommodate present and future management information needs was developed. Detailed plans to integrate all of the control points of the enterprise were the fundamental requirement. Subsequently, advanced control strategies were developed for both CRAMTD production lines, MRE, and Tray Pack. The MRE production line was selected to demonstrate the use of these advanced control strategies. A total of seven areas of quality control were addressed in this production line. All activities, whenever possible, were documented in Technical Working Papers. A list of technical working papers pertaining to this STP is attached as Appendix 4.2.

1.2.1 Solbern & FEMC Filling Systems

Weight control was the major concern in the CRAMTD filling systems, as beef and vegetable fill weights are both critical factors for the sterilization process, and affecting the cost of the rations. It was STP#12 objective to develop an automatic control scheme for the beef and vegetable filling systems. This control system needed to demonstrate an advanced feedback control strategy which utilizes statistical techniques to analyze and control the filling processes.

The Solbern system lended itself to an automatic weight control system by adding a check weigher to the system with a feedback control loop to control the depth of the cup while being filled. Tight control on the fill weight would reduce the required overfill and therefore lowering the raw material cost, as well as shortening the required retort processing time and therefore

lowering the processing cost and potentially improving the product quality. The implementation and testing of this check weigher was done under STP#14. Collection of data from the check weigher by the Supervisory Control and Data Acquisition (SCADA) node and storage of this data in the plant database was accomplished under STP#16.

The FEMC filling system lended itself to Statistical Processes Control by collecting at set intervals a number of fill weights on an off-line scale. This data would then be send to the SCADA node which would analyze the data and take corrective actions if necessary by adjusting the FEMC filler. Implementation of this control strategy was accomplished under STP#16.

The recommended control strategies became part of a "Proposed Integration of MRE Pouch Line for Demonstration Runs", submitted by the Principal Investigators of STP#16 on July 27, 1994 to the Technical Steering Committee (see Appendix 4.5). The integrated system for the CRAMTD Pouch Line was successfully demonstrated at the Annual Contract Briefing on June 19, 1996.

1.2.2 Gravy Preparation System

Control over a batch process is a major issue in the industry. Not only are controls of the process variables, such as time and temperature important, but also the control over materials and their quantities that were added to the batch by the operator. The gravy preparation system was used to develop the required control strategies that will lead to the production of high quality products.

The specifications for a liquid and slurry food preparation control system were developed. IDEF0 functional architecture was used to model the system. A computer network architecture was then designed that would integrate all functions performed by the required mechanisms to accomplish the system's objectives. Each mechanism was described in detail. The design of the PLC control functions, the recipe development interface and the operator interface were then specified. The control system specification was such that it is compliant with the batch control protocol (SP-88).

The original objective was to "partner" with STP#14 to share in the cost to acquire and install a gravy preparation system as part of the CRAMTD process, and the control specification would become part of this acquisition. However, implementation of this system was postponed/canceled due to a change in priorities and lack of funding to support this acquisition.

1.2.3 MRE Pouch Packaging System

Major concern in the pouch packaging line was the collection of critical process data, such as product temperatures, sealing conditions and the traceability of raw materials. In many cases, the controlling sensor is the same sensor that is used for recording the process variable, or critical data is not monitored or measured in the wrong place. In cooperation with STP#16 various temperature sensors were added to the system to measure the ingredient temperature inside the Solbern filler, the FEMC filler, the Oden liquid filler and the pouch prior to sealing. Repeated attempts to equip the Tiromat with additional sensors to record the sealing conditions independent from the controlling sensor failed due to lack of response from the vendor. Therefore, the current system still relies on the monitoring of the controlling sensor for seal plate temperature and pressures, a practice that is not endorsed by this project. To monitor the flow of materials through to the MRE pouch packaging system, two bar-code scanning systems were

added. One system is a wireless scanner that will be used to record any new lot of material that is added to the system by logging the material bar-code and the location code where it was added. The second system consist of two fixed bar-code scanners, located in the retort crate loading stations, which will scan the crate id tag as it enters the loading station.

All information is collected by a line controller and send to the SCADA node. The SCADA node will make the data available to the operator on the View node. The data can also be send to the database for permanent storage. However, the database lacks still the design of a Work-In-Progress module that would integrate this information with the material management module and a recipe module.

1.2.4 Sterilization System

The sterilization or retort system in a plant is a key processing operation that needs to be controlled and monitored within tight tolerances. Review of process data by a plant processing specialist is cumbersome and can lead to errors. It is anticipated that a lot of this review can and will be done, in the future, electronically with a much higher degree of accuracy.

Extensive work was done around the retort system. Efforts concentrated on the integration of the retort control system with the plant database, adding additional sensors for monitoring critical process parameters and adding a system that would monitor the crate id's that are being retorted. The accomplishments of these objectives resulted in a system that gives one the capability to review process records electronically. Regulatory Agencies are currently reviewing requirements for electronic record keeping and signatures. Once a final rule has been made in this area, a major step can be made in reduction of the paper work and time involved in reviewing processing records. Also, electronic review of records can be far more reliable in detecting any process deviations.

Most of the hardware and software upgrades have become part of the standard control system that Stock America installs with their newer retort systems. In 1996, a contract was received from Stock America to develop a prototype crate tracking system that they could commercialize for their automated crate handling system. The logic, originally developed for the CRAMTD process was enhanced to assure that inadequate processed materials are not automatic unloaded from retort crates.

1.2.5 Quality Control Lab

The major effort in the quality control lab was to develop and implement quality control procedures. This effort included the acquisition of some specific quality control hardware to supplement the equipment already present, and the implementation of the Quality Control database module developed under a previous Short Term Project. Quality control procedures in the form of product inspection procedures, test methods, lab procedures. etc. were documented and implemented in the quality control database.

In addition to the traditional quality control functions, STP#12 developed and implemented also a Supplier Evaluation System. Performance characteristics of a supplier is critical in a Just-In-Time manufacturing system. A system was developed that rates the performance of a supplier based on a quality audit of the vendors facility, timeliness of product delivery, cost per unit, and quality control data at point of product receipt. This system utilizes a graduated grading technique that encourages the vendor to produce to target rather than within specification limits.

1.2.6 Material Tracking

Material Tracking is a key component in the quality control effort of a plant, not only as far as the warehouse movements of materials but also the movement of materials on the plant floor and their use in the production process to produce new materials.

Under this heading various efforts were undertaken to enhance our capability to track material in the plant. A bar-code printer was acquired to label all product in the plant with a unique lot code. Also each area in the warehouse and in the plant was bar coded with unique location codes. A portable PC with bar-code scanner and a wireless network were then acquired and installed that enabled the user to record any material moves within the plant on a real time basis in the CRAMTD database.

Use of bar code technology to mark and scan all material as they are moved through the warehouse and plant will greatly reduce any data input errors in a material tracking system. Automatic data collection systems help to ensure that the product data base integrity is maintained, manual identification and human misinterpretation will be eliminated, reports may be easily generated and CRAMTD line shutdowns and delays will be minimized. Efficient material handling and tracking within the CRAMTD system will provide increased throughput and customer satisfaction of perpetual inventory, streamlining product recall procedures, and real time data for invoicing. Moreover, the use of bar-coding and radio frequency in the warehouse will minimize the excessive use of hold areas due to manual, visual inspections. The integration of Management Information System and warehouse control system will lead to a competitive edge for advanced manufacturing system.

1.2.7 Environment/Sanitation/Calibration Control

A major effort in this area was concentrated on sanitation control. Sanitation control is becoming increasingly more important to the food industry, especially in light of recent enacted HACCP regulations. Conventional methods for sanitation checks require the "plating" of swab samples, a procedure that can take several days. In this STP, we concentrated on a rapid method that measures a by-product of microbial respiration. This method is capable of checking the sanitary condition of a surface within 5 minutes. Short turn around time in sanitation checks can be a tremendous advantage while checking the effectiveness of cleaning procedures.

A study on the reliability of ATP bioluminescence for measuring surface sanitation and a comparison of different models and different brand names of luminometers was performed. All units performed well with either ATP standard or pure microorganism culture or both. It was concluded that the ATP bioluminescence is a rapid, reliable and relative inexpensive method for measuring surface sanitation, which makes this technique a potentially powerful addition to any food service of food processing HACCP program.

1.3 Recommendations

While a strategy was developed to support level 2 and level 3 CIM, the implementation of sensors and quality control strategies was completed at level 2 CIM. It is recommended that a follow on project would complete level 3 CIM according to the SP-88 model. At level 3 CIM various CIM modules such as material management, production schedule management, quality data management, recipe management and information management would be integrated with the production management to form a homogeneous system.

Tracking of materials on the plant floor is a fundamental requirement for CIM system. While most existing material tracking systems are based on batch mode processing, this project demonstrated the benefits of real time tracking system, a system that is in direct communication with the plant database. To demonstrate this technology, RF technology and a laptop computer were used. Advances have been made in computer technology, allowing the same implementation on handheld scanning devices which are in direct communication with the database. It is recommended to upgrade the CRAMTD warehouse management system from the prototype system to a commercial system.

Statistical Process Control is an important facet in production quality control. The implementation of SPC in plants with unskilled workers is difficult and often results in inappropriate application of corrective actions. A SPC program was developed to collect data from a scale, and apply various complex run rules to verify that the process is in statistical process control. It is recommended that the capability of this program be broadened to accept inputs from various communication ports and to accept manual entered data. This technology can be implemented right away in any ration production plant without significant capital layout.

A second, similar SPC program that deals with attribute data such as pouch defect data should be developed. This program should keep track of various type defects, log their location on the pouch, apply various complex run rules to identify when the process is out of control, and store the data in a relational, PC-type, database for off-line statistical analysis. Again, once developed, this type of application can immediately be implemented in a production facility without the investment in supervisory control systems or client-server database management systems.

Retort crate tracking was demonstrated in the CRAMTD facility. Based on this demonstration, Stock America has commercialized this technology and are using it in their automatic retort systems.

Regulatory agencies are making progress in defining the requirement specifications of critical sensors and measuring systems. Once these regulations are published, a critical review should be performed in the CRAMTD facility to ensure that we comply with these regulations and if not, sensors and/or measuring systems should be replaced in critical areas to comply with the regulations

Regulatory agencies are also making progress in the area of electronic data storage and review. Once these regulations have been published, a critical review should be performed on the CIM system to make the CRAMTD facility in compliance with these regulations. Also, at that time a project should be proposed that would implement additional control and review strategies that would maximize the utility of electronic records.

2.0 Program Management

STP#12 started September 1, 1992 based on a technical proposal dated June 19, 1992 and cost proposal dated June 29, 1992, that was submitted to the DLA on June 30, 1992. Final approval for the project was received on September 30, 1992, with a retroactive start date of September 1, 1992. However, due to limited funding in the CRAMTD program, the project was only partially funded and the activities started at a much reduced level than described in the proposal. Full funding was received on July 9, 1993. Extension of completion date to March 29, 1995 was requested on August 31, 1994. A second extension of completion date to July 29, 1995 was requested on April 4, 1995.

The broad objective of the project was to design, develop and demonstrate a prototype system of hardware and software to optimize the use of sensors and detectors for manufacturing control in major parts of the CRAMTD operation. STP#12 was a three-phase work activity. The three phases had the following general objectives:

Phase I: Develop and update a manufacturing control plan for quality control, process control and material tracking control. Specify appropriate hardware and software to demonstrate optimal use of selected sensors, detectors and data entry stations.

Phase II: Acquire hardware and software necessary to implement part of the manufacturing inspection and control demonstration plan.

Phase III: Document and demonstrate the manufacturing inspection and control plan.

The work activity and status are illustrated on the attached figure 1, CRAMTD STP#12 "Sensors and Quality Control Strategies in the Integrated Manufacturing System," Time and Event Milestones (Appendix 4.1).

2.1 Summary of STP Accomplishments

Advanced control strategies were developed for both the Tray Pack and the MRE production line. The MRE production line was selected to demonstrate the use of these advanced control strategies. The following unit operations in this production line were addressed in the demonstration plan:

1. Solbern & FEMC filling systems
2. Gravy preparation system
3. MRE pouch packaging system
4. Sterilization system
5. Quality Control Lab.
6. Material Tracking
7. Environment/Sanitation/Calibration Control

A total of 11 Technical Working Papers were written to document the details of this project.

The sensors and control strategies were implemented and successfully demonstrated at the Annual Contract Briefings on March 8, 1995 and on June 19,1996.

3.0 Short Term Project Activities

3.1 STP Phase I Tasks

3.1.1 Flow Sheet and Layout (Task 3.3.1.1)

The process layout and product flow diagram were updated for the CRAMTD phase II facility and are reported in Technical Working Paper #75.

3.1.2 Control Plan (Task 3.3.1.2)

Based on the production flow sheets, a control plan was developed for the MRE and Tray Pack production lines. This plan was documented in Technical Working Paper #75, and addressed the following areas:

1. Raw Material Control
2. Process Control
3. Finished Product Control
4. Material Tracking Control
5. Environment Sanitation Control
6. Instrument Calibration Control

This manufacturing control plan was then used to develop a USDA required "Partial Quality Control" program for the production of Beef Stew in MRE pouches. This PQC program was approved on July 13,1993 by the USDA, and was used in subsequent production runs of MRE beef stew. The PQC program was issued as Technical Working Paper #90.

3.1.3 Requirements (Task 3.3.1.3)

Requirements for sensors and controllers were identified for each specific control point, as identified in the control plan and were documented in Technical Working Paper #75.

A rapid microbiological sensor for HACCP control was identified as a critical sensor in the overall STP#12 project. Before a decision could be made regarding the applicability and requirement specification of such new technology, various units were obtained and tested on suitable "real-world" samples. Food samples as well as equipment surface samples (sanitation), were used in this evaluation. The results of this study were documented in Technical Working Paper #107

3.1.4 Recommended Demonstration Plan (Task 3.3.1.4)

A recommended demonstration manufacturing control plan with sensors/detectors, data entry stations and software for various areas of control was developed. This demonstration plan was a

subset of the overall control plan as developed under task 3.3.1.2. The areas which STP#12 focused on were:

1. Solbern & FEMC filling systems
2. Gravy preparation system
3. MRE pouch packaging system
4. Sterilization system
5. Quality Control Lab.
6. Material Tracking
7. Environment/Sanitation/Calibration Control

Details of the demonstration plan are described in Appendix 4.3

3.1.5 Specification (Task 3.3.1.5)

Detailed specifications for each of the areas identified in the demonstration plan were developed and quotations solicited. Investigators from STP#12 started to work closely together with representatives from STP#14 and STP#16 at this phase in the project to ensure the implementation and integration of quality control strategies in the overall CRAMTD CIM system.

The quality control requirement specifications for the Solbern and FEMC filling systems focuses on temperature and weight control and are documented in Technical Working Paper #79. STP#14 acquired a check weigher that complied with those specifications. Final Technical Report (FTR) 22.0 documents the capability of this check weigher.

Specifications were also developed for a proposed gravy preparation system. The control system demonstrated CIM at level 1, 2 and 3 and was compliant with SP-88 a batching protocol developed by the International Society for Measurement and Control. The specifications for this control plan were documented in TWP#85. The gravy preparation system was not acquired by STP#14 due to budget limitations of this project.

In cooperation with STP#16, specifications were developed that implemented a control plan for the MRE packaging line. Included in this control plan were weight controls for the filling systems, temperature monitors for the ingredients and bar-code scanners for the in-coming and out-going products. Further details on the specifications and cost of these controls are documented in the final technical report of STP#16, FTR 23.0.

In cooperation with Stock America, a detailed specification was prepared that demonstrated advanced sensors and quality control strategies around the retort system as well as integration of the retort control system in the CRAMTD CIM system. Details of the specification were documented in Technical Working Paper #112.

Various sensors were specified for the quality control lab to enhance its capability to measure and record the quality of combat rations. A complete description of the required quality control checks for MRE pouches and half steam table tray is described in Technical Working Paper #114, including the specification of hardware items that were not available in the lab.

In addition to measurements and sensors, a methodology was also specified to review the quality of raw materials received. This methodology, also referred to as "Vendor Evaluation", can be used to grade a vendor based on his past history and to determine which vendor could be prime vendor for a specific material. A description of the concept of Vendor Evaluation is documented in Technical Working Paper #97.

The specifications for material tracking sensors were documented in TWP#111. It encompassed material tracking in the warehouse and on the plant floor. The material tracking strategy was based on bar-code scanners, data entry stations and wireless networks to communicate in real time with the database. The production floor scanners were integrated with the MRE production line controller and with the retort control system.

In the area of sanitation, STP#12 evaluated various rapid microbial counters to test the applicability in regard to accuracy, repeatability and precision. All instruments used the ATP level of the sample to determine "contamination" . Details of these tests are reported in TWP#107.

3.1.6 Evaluation and Selection (Task 3.3.1.6)

Various quotes from hardware and software vendors were evaluated and a selection was made to acquire the best valued items. This information was presented at a management and technical review meeting on December 16, 1993.

3.1.7 Review (Task 3.3.1.7)

A Phase I review meeting was held on December 16, 1993 with the Program Manager/COTR. The individual manufacturing process control plans with their respective hardware and software requirements were presented and are documented in appendix 4.4. The program manager accepted the recommendations.

3.2 STP Phase II Tasks

3.2.1 Obtaining Approvals (Task 3.3.2.1)

Approvals to acquire hardware and software for the Quality Control Lab, Material Tracking and Retort Control were requested and received from Vincent Morano, the administrative contracting officer.

3.2.2 Ordering and Receiving (Task 3.3.2.2)

After approvals were received, purchase orders for hardware and software were placed. All requested items were received in a timely manner.

3.2.3 Installation and Checkout (Task 3.3.2.3)

Hardware and software for material tracking were installed and checked out. The system included a wireless network system to be used in the warehouse. A router to link the wireless network and the hard wired network was placed in the warehouse. The data entry terminal for material tracking in the warehouse was a laptop computer with a serial port scanner. A bar-code printer was placed in the QC lab and was made available for general use. All purchased systems were tested satisfactorily.

Hardware and software items for the QC lab were installed and tested as received. All systems performed satisfactorily. To integrate the off-line scale in the overall CIM system, a software program with SPC capabilities was developed (PMCOMM). This program, based on Visual Basic®, can operate as a stand alone unit or can be integrated into the CRAMTD CIM system. The application uses statistical process control techniques and incorporates DDE and ODBC functionality. DDE gives it the flexibility to transfer the data dynamically to other Windows based programs. ODBC gives it the flexibility to transfer the data directly to a data base like Oracle. Technical Working Paper #92 describes the functionality of this application in more detail.

In the Quality Control area, STP#12 also developed a software application that tracks the performance of a raw material vendor. This application scores the performance of a vendor for specific products based on various weighted factors such as quality, delivery, price, etc. This score could then be used to determine who the preferred or "best valued" vendor is for a specific material. The application was written within Oracle Forms and Microsoft Excel. Excel was interfaced with the Oracle database to conduct data analysis and display resulting data in graphical form. The Excel analysis application queries the database for product quality data over a given time frame and scores this quality data based on graduated scale and weight factors. The second Excel application queries the data base and displays historical data vendor rating data as function of a product. A detailed description of this system can be found in Technical Working Paper #104. The installation and check out was completed satisfactorily and the application was demonstrated at the DPSC - IDE conference in Philadelphia on October 25 and 26, 1995.

A government owned, Stock 1300 retort with ICON control system, was installed in the CRAMTD facility. The installation and start-up of the system was completed by the end of February 1994. The system was then evaluated and validated by the FDA on March 8 and 9 1994. Software and hardware upgrades were installed and tested late January, 1995. Minor software modifications were made by STOCK in June, 1995 to further improve the performance of the system.

The retort control system was also integrated with the CRAMTD database. Critical data of each cook in the 1300 retort is recorded in a file that is moved to a specific network drive after the cook is completed. In cooperation with STP#16, a computer program module was developed, using Visual Basic®, that reads this file and uploads the records to the Oracle database. Several query forms were designed, to display the retort data for process evaluation. A second application program was developed, using Oracle Forms, which will be used in the post retort packaging area. This application will check if the product that is being unloaded has been adequately processed. A detailed description of these activities are documented in Technical Working Paper #112

3.3 STP Phase III Tasks

3.3.1 Performance (Task 3.3.3.1)

The rapid microbial testing unit performance was tested for line sanitation. It was concluded that the ATP bioluminescence is a rapid, reliable and relative inexpensive method for measuring surface sanitation. Detailed results of this study are documented in TWP#107. One of the tested units, the Biotrace-Multi-lite, was recommended for use in the CRAMTD plant to replace regular plate count methods.

The performance tests of the retort software and hardware upgrades were conducted during February, 1995 by means of temperature distribution studies as specified in Technical Working Paper #67. As ballast load, MRE pouches filled with water were used. The overall performance of the retort increased in the critical area of pressure control during cooling due to the installation of an analog vent valve and the measurement of pressure in the processing vessel rather than in the storage vessel. The hardware upgrades had no negative effect on the come up times, in fact a slight improvement was measured in the time required to reach uniform retort temperatures (t_{1avg}= 8.6 minutes versus 9.4 minutes)[1]. During subsequent retort runs with different types of containers (#10 cans and glass containers), it was observed that the tuning of the pressure control loop is container sensitive. Additional changes to the PLC software were made by Stock America that allow for the tuning of the pressure control loop as function of the selected program.

3.3.2 Documentation (Task 3.3.3.2)

An operational guideline was developed for the operation of the Stock 1300 retort and training was given to plant personnel in the operation of the system. The operational guideline was issued as Technical Working Paper #113

Detailed instructions were documented for the Quality Control Lab in the form of an inspection plan, inspection procedures, and lab procedures and was issued as Technical Working Paper #114

Various technical working papers were prepared to document the implementation of sensors and quality control strategies in the integrated manufacturing system which contains operation guidelines (Technical Working Papers #90, 92, 104, 107).

3.3.3 Demonstration (Task 3.3.3.3)

STP#12 worked closely together with STP#14 and STP#16 to insure the integrated demonstration of the various components.

Demonstration of the computer integrated system was given during the Annual Contract Briefings on March 8, 1995 and June 19, 1996. A separate demonstration of the Vendor Evaluation system was given at the Defense Personnel Support Center (DPSC) on April 14, 1995.

A presentation was also given during the IFT annual meeting at Atlanta by Shu-Ying Wang and Don Schaffner on "The Use Of ATP Bioluminescence For Rapidly Measuring Surface Sanitation".

A presentation was given at the third International Conference on Automation Technology, July 1994 by Argon Chen on the subject of "Computer Integrated Control System for Liquid and Slurry Food Production" (Technical Working Paper #85).

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[1] See Technical Working Paper #67: "Development of Methodology for Conducting and Analyzing Temperature Distribution Studies for Evaluation of Retort Processes"

4.0 Appendix

4.1 Figure 1. CRAMTD STP#12 Time and Events Milestones

4.2 List of Technical Working Papers

4.3 Demonstration Quality Control Plan

4.4 End of Phase I Review Documents

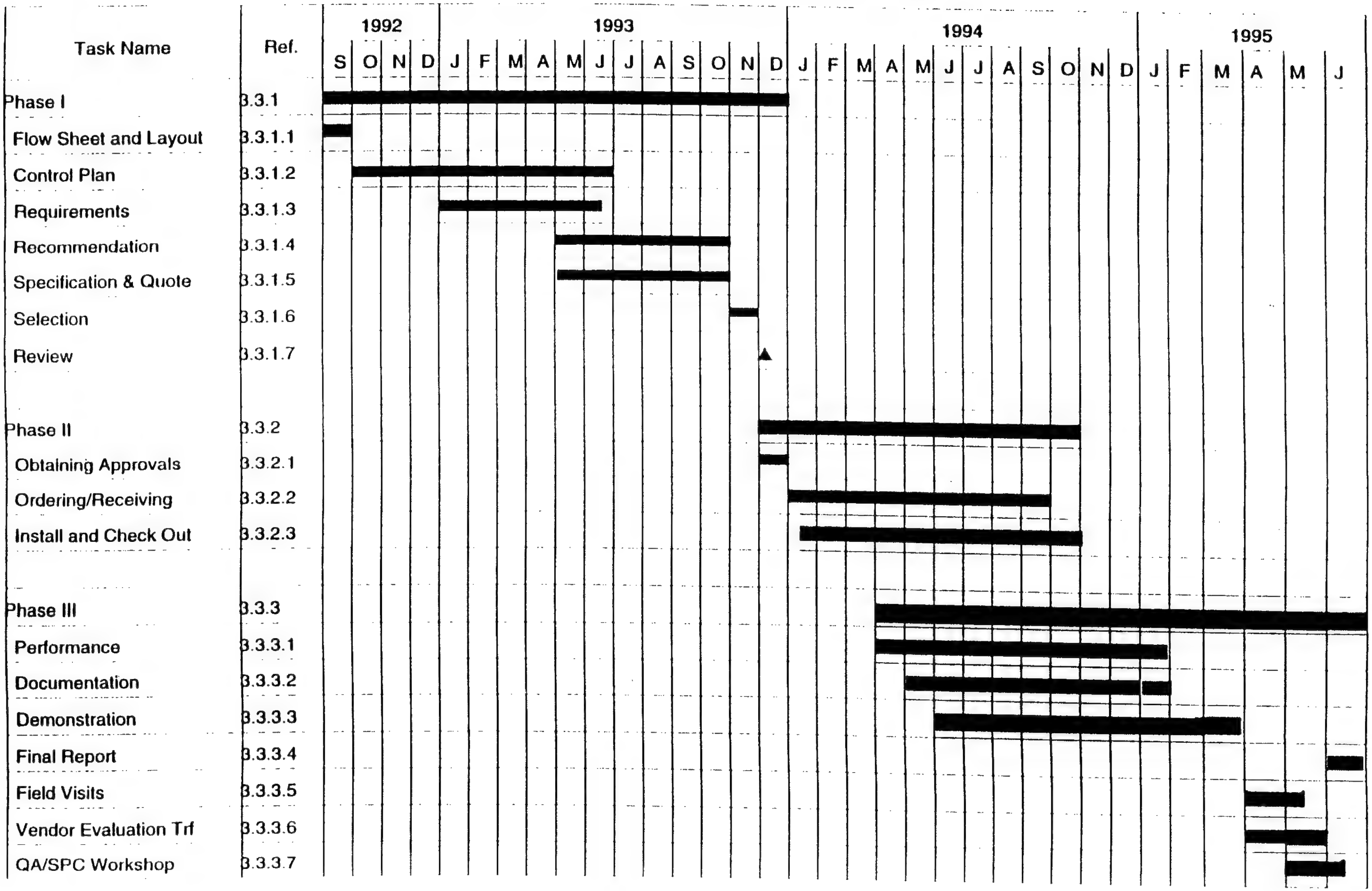
4.5 Proposed Integration of MRE Pouch Line for Demonstration Runs

Final Technical Report (FTR) 25.0 - STP #12

Appendix 4.1

Figure 1, CRAMTD STP#12 Time and Events Milestones

Figure 1 - CRAMTD Short Term Project #12
Sensor Systems for Process Quality Control
Projected Time & Events and Milestones



Appendix 4.1

Final Technical Report (FTR) 25.0 - STP #12

Appendix 4.2

List of Technical Working Papers

List of Technical Working Papers

Final Technical Report (FTR) 25.0 - STP #12

Appendix 4.3

Demonstration Quality Control Plan

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

Interdepartmental Communication

Food Mfg. Technology Facility
120 New England Avenue
Piscataway, Busch Campus

June 1, 1993

TO: E. A. Elsayed
S. Albin
D. Schaffner
J. Luxhoj
J. Rossen

FROM: Rieks Bruins HBB

RE: Hardware and Software Items

On May 17, 1993, Dr. Elsayed and myself met to discuss task 3.3.1.4 in short term project #12. This task requires the development of a recommended demonstration manufacturing control plan with sensors, detectors, data entry stations and/or software for the various areas of control. This plan should: 1) demonstrate the optimal use of sensors, quality control and computer integration in selected areas, 2) demonstrate the benefits of using (advanced) sensors, detectors, computers, software, etc., 3) fit within the budget constraints of this project. The preceding task (3.3.1.3) has resulted in a list of control points that should be considered in a manufacturing control plan. It is from this list that we need to select items that fit within the constrains of task 3.3.1.4. The following summarizes our discussions and proposes a recommendation regarding the demonstration manufacturing control plan.

Process Control

1) Solbern & FEMC Filling System:

Beef and Vegetable fill weight are critical factors in the thermal process of beef stew. Tight control on fill weights reduces the degree of over processing and increases product quality and process capacity. The fill weights are determined by the integrated filling system which consist of two individual controlled fillers: a Solbern filler for beef and a FEMC filler for vegetables.

The Solbern filling system is currently equipped with a check weigher for monitoring purpose. STP#14 plans to upgrade this check weigher to one which has the capability to reject/divert under and over weights. We believe that STP#12 should develop and implement advanced feedback control strategies around this filling system. The check weigher data should be analyzed statistically and in-line adjustments be made on the Solbern filler to control beef fill weight. This activity needs to demonstrate state-of- the-art feed back control strategies. This project would require the cooperation from STP#14, STP#16 and Solbern. A price quotation for a check weighing system with servo motor feed back control has been

obtained by the investigators of STP#14, and indicates a capital need of **$10,000.**

The vegetable fill weights are controlled by adjustment of the cup depth in the FEMC filler. However, no in-line measurement system is in place to measure and control this weight. We believe that STP#12 should use this system to demonstrate advanced control strategies which are based on statistical process control. For example, vegetable fill weights should be checked by frequent sampling. Empty cups can be filled by the FEMC filler and checked on a scale. The scale can be hooked into a data collection system which can perform statistical analysis. An algorithm, based on predefined run rules, can alarm the operator and indicate the type of adjustment that should be made. This task should also investigate how to close the control loop and assess the benefits of closed loop control versus SPC control. The capital budget for this project is set at **$5,000** and would cover the cost of a scale, a PC and I/O board.

2) Gravy Preparation System

Gravy viscosity is considered to be a critical process factor and affects the heat transfer during the retort process. Consistency of the gravy is determined by the ingredients and by the temperature and time of the gravy preparation process. STP#14 plans to specify and sub-contract a gravy preparation system. We believe that STP#14 and STP#12 should be cooperating in writing the specifications of the control system for the gravy preparation system. STP#12 has put aside **$10,000** of it's capital budget to finance an advanced control systems for this system.

3) Tiromat Operations

Seal integrity is a must in obtaining hermetically sealed containers. Various factors affect seal integrity. Seal contamination during filling is probably the leading cause for inadequate seals and needs to be resolved as part of the cup dumping system. Based on CRAMTD's experience, a second cause for inadequate seals is a non-uniform seal plate temperature. The current control system relies on a single temperature measurement in the middle of the seal plate. We believe that STP#12 can improve this control system by developing a temperature monitoring and control system with multiple temperature sensors embedded in the seal plate. Algorithm would be developed to give early warning to the operator to indicate an out of control situation.

Also, we believe that STP#12 should implement sensors and a high speed data acquisition system for the evacuation system to better monitor the evacuation rates in the top and bottom chambers. An unbalanced evacuation of those two chambers can cause movement of the film, product spills into the seal area and inadequate sealed pouches.

This project requires the cooperation of the STP#14 investigator, as well as T W Kutter. Part of this task is also to determine if the control is to be done within the existing PLC or if a separate PC based data acquisition and control system should be purchased. The capital budget for the above control functions has been set at **$10,000**

4) Sterilization Operation

Regulations require that retort process be monitored by manual reading of mercury in glass thermometers and recording of temperatures on continuous chart recorders. Such a system doesn't lend itself to demonstration of computer integrated manufacturing. We believe that STP#12 should identify a vision of computer integrated manufacturing around the retort process and work with the USDA to identify regulatory issues that need to be addressed before they will allow such a system to become part of a production system. A preliminary capital budget has been set aside for this area in the amount of **$35,000.** These funds are needed to upgrade the retort control system in order to integrate it in the CRAMTD CIM system. The remainder of the budget will be used to acquire hardware and software that demonstrates the use of advanced process control around the retort process.

Product Quality Control

Quality Control Laboratory

The quality control lab is a key function in product quality control of the CRAMTD process. Many measurements are performed off-line in the lab, ranging from microbial work to analysis of the finished product. Various (advanced) analytical instruments are available to perform these measurements. We believe that STP#12 should identify and demonstrate advanced quality control measurements/strategies in the areas of raw material checks, in-process checks and finished product checks. Results from STP#3 should be used to identify advanced sensing technologies as well as the work which is ongoing under STP#12 in the area of rapid microbial counting. In cooperation with STP#16, a laboratory information system needs to be developed for the QC lab. This LIM system needs to store and link the data to production and lot number data. Statistical software needs to be purchased/developed to conduct analysis which detects trends in the quality data. STP#12 anticipates a capital budget in this area of **$25,000.**

Material Tracking

Material tracking is a key element in quality control procedures. The ultimate objective is that one can determine for each retort cook: a) what went into the container, b) how the container was processed, b) to whom the product was shipped. To accomplish this objective, we need to track materials from the warehouse, through the production process and to the shipping department. Also, quality control samples taken from the process floor need to be tracked to the QC lab for proper reference between QC data and on-line process data. Coding of batches, sub batches and containers at strategic places in the process is essential. To demonstrate material tracking in the CRAMTD process, several PC's need to be located throughout the plant and be equipped with bar code readers and printers. A capital budget has been set aside for this task of **$15,000.**

Environmental/Sanitation/Calibration Control

The controls in these areas are essential in order to comply with Good Manufacturing Practices (GMP), Hazard Analysis Critical Control Points (HACCP) and the various Military specifications. Control points with appropriate sensors were identified and a selection need to be made from this list to demonstrate that these areas are part of a total quality control system. A capital budget has been set aside for these areas of **$5,000.**

Please review this list and be ready to discuss it during our next meeting. Each of these tasks need to be assigned a coordinator. The budget assigned to the various areas is tentative. At this time we need to develop a detailed control strategy for each of these areas and identify exactly what is needed to accomplish the objectives of STP#12.

Rieks

c.c.
John Coburn
Tom Boucher
Ted Descovich
Alex Sigethy

Final Technical Report (FTR) 25.0 - STP #12

Appendix 4.4

End of Phase I Review Documents

CENTER FOR
ADVANCED
FOOD
TECHNOLOGY

Food Manufacturing Technology Facility
120 New England Avenue
Piscataway, NJ 08854
908/445-6130 FAX: 908/445-6145

November 29, 1993

Defense Logistics Agency
ATT: DLA-PRM/ Russ Eggers
Cameron Station
Alexandria, VA 22304-6100

Re: STP#12 End of Phase I Review

Dear Russ:

STP#12 has completed its tasks in phase I and needs to proceed with phase II, the acquisition and installation of the selected hardware and software items to be used for the demonstration. According to the STP#12 proposal, a management and technical review was held with the CRAMTD technical committee on October 8, 1993. This committee consisted of John Coburn, Alex Sigethy, Ted Decovich, Tom Boucher and myself. During that meeting STP#12 reviewed their proposed demonstration manufacturing control plan.

As you might know, STP#12 developed an overall manufacturing plan for the advanced combat ration manufacturing plant. This plan is outlined in technical working paper #75 which was recently sent to you. From this extensive list of control points, seven areas were selected for the demonstration control plan. These areas were discussed under the following titles:

Retort CIM Integration
Quality Control Lab
Sanitation Control
Material Tracking Control
Weight Control
MRE Packaging Line Integration
Gravy Preparation Control System

The proposed demonstration plan, made by STP#12, was reviewed by the technical committee and this memo is intended to inform you of their recommendations.

Attached are the overheads that were used during this presentation. These overheads speak for themselves and outline the objectives in each of these areas; the hardware and software requirements, the features of the control system once implemented, the pending issues, and the cost benefit of the activity.

I will now discuss each of these areas and advise you of the recommendations of the technical committee. Please review this information and let me know if you concur with the recommendations. Your concurrence will enable us to proceed with phase II and III of this project.

Retort CIM Integration

To meet the objective of computer integrated retort system, we need to either upgrade the control system on our current multi mode retort at a cost of $45,000 or we need to acquire a second single mode, used retort with a control system that is CIM compatible (Stock quote: 1100/4 basket retort: $120,000). After a discussion of the pros and cons, the technical committee decided that we should first investigate the possibility to acquire a second, commercial sized, retort system. This would give us the required hardware and software for CIM integration and would also give us the much needed extra retort capacity for the pouch qualification runs and for the demonstration runs. Two options to acquire an additional retort will be pursued; first, we will talk to DoD and inquire about the availability of a retort module and second, we will contact Stock to see if there are used retorts available at this moment. No matter which options we pursue, some funding will be needed to custom tailor the control system and make it 100 % CIM compatible (estimated cost $10,000).

Quality Control Lab

To demonstrate a fully functional lab for combat ration quality control, additional quality control equipment is required. After review of the specific needs in the quality control lab, the committee recommends to acquire the necessary items as specified in the hand out (total cost:$ 20,800).

Sanitation Control

The requirements for sanitation control were reviewed. STP#12 recommends to continue the lease of rapid microbial testing equipment for another year to complete the reliability and repeatability testing of this technology. The technical committee agreed with this recommendation. It also recommended to purchase the chlorine tester for water quality monitoring (cost: $150).

Material Tracking

STP#12 recommends to implement a complete material tracking system from raw materials to finished product. The required data entry stations with bar code readers will be integrated as much as possible with other work stations in the plant. At the recommendation of the committee, STP#16 and STP#12 will develop an information layout for the plant, which will identify the physical location and functionality of each work station. This plan will be reviewed by the technical committee before final recommendations are made. (cost: tbd)

Weight Control

Weight control is identified is one of the critical areas for process control. Two weight control strategies were identified by STP#12, one continuous check weighing system with feed back and feed forward control (Solbern filler) and one off-line check weighing system with SPC capabilities (FEMC filler and Oden filler). The document describing the proposed control specification for the continuous check weighing system was given to STP#14 with the request to add the control specification to the hardware specification of a check weighing system.. (Cost: STP#14).

The committee agreed with the recommendation of STP#12 to proceed with the purchase of the balance for off-line check weighing control. (Cost: $1,566)

MRE Packaging Control

A preliminary control plan/strategy was developed by STP#12 for the MRE packaging line. Several control and monitoring functions have to be performed around this packaging line. At the current time, the line exists of several control systems, each controlling one operation. STP#12 recommends to integrate these controllers by means of a supervisory controller which communicates to each controller and also communicates with the shop floor computer (SCADA node). The specification of such a system falls under STP#16. STP#12 has given the preliminary control plan to STP#16 for further refinement. (Cost: STP#16)

Gravy Preparation System

A control plan was developed for the gravy preparation system. The hardware of this system needs to be specified by STP#14. The document describing the proposed control specification for the gravy system was given to STP#14 with the request to add the control specification to the hardware specification of the gravy system.. (Cost: STP#14).

Sincerely,

H B Bruins

Rieks Bruins, Manager
Food Process Development

RB:d
cc: John Coburn
Ted Descovich
Alex Sigethy
Tom Boucher

STP#12, Phase I, Review: 12/6/93, brief narrative for the various slides

Appendix 4.4 - 4
This slide represents the overall agenda of the phase I review meeting. The control plan developed by STP#12 includes quality control, process control and material tracking. The project determined what sensors would be required, how often the data needed to be read, what variable would be controlled based on the sensor output and how it would integrate with the CIM system

Appendix 4.4 - 5
This slide estimates the cost involved to implement the various control requirements for the demonstration plan

Appendix 4.4 - 6 through 8
An overall review is given in the next three slides of the methodology that was followed to determine the overall control strategy for the combat ration process. A more detailed explanation on how to interpret this information can be found in TWP#75. The figure on page 6 shows the process flow for Beef Stew for the MRE production line and identifies the various process steps that require control. The table on page 7 identifies the variables that need to be controlled and/or monitored in each of the identified process steps. The figure on page 8 identifies the various controllers and monitoring stations that are needed to read and display the output signals from the sensors identified in the previous table.

Appendix 4.4 - 9 through 13
These slides review the anticipated requirements, features, issues and cost benefit of the CIM integration of the 1100 Stock multi-mode retort system. The current control system on this unit is propriatory and needs to be replaced by an Allen-Bradley based control system. Stock America has such system available (ICON2000) and a review was given of the features of that system. As an alternative, we discussed also the acquisition of a commercial sized retort and the benefits associated with that option.

Appendix 4.4 - 14
This slide reviews the requirements for the quality control lab

Appendix 4.4 - 15
This slide reviews the requirements for sanitation control in the plant

Appendix 4.4 - 16 through 20
In these slides an overall review was given for the material tracking strategy in the CRAMTD plant. The reader is referred to TWP#111 for a detailed explanation of the strategy.

Appendix 4.4 - 21 through 26
The following six slides explain the requirements, features, issues for two weight control system. The Solbern filling system will use a check weigher for continuous monitoring and controlling the fill weight. The FEMC and Oden filling systems will be monitored and controlled based on Statistical Process Control techniques. More details on these control strategies are given in TWP#79.

Appendix 4.4 - 27 through 29
These slides explain the requirements, features and issues for the MRE line controller. At issue was how to integrate various pieces of equipment into a integrated production line. Page 28 shows the overall architecture of a proposed CIM system for the MRE line. This project was later on executed by STP#16 and more details can be found in their final report.

Appendix 4.4 - 30 through 34
The last five slides explain the requirements, features and issues of a CIM based control system for the gravy preparation system. A more detailed explanation of this proposed system can be found in TWP#85

STP#12
PHASE 1 REVIEW
12/16/93

IDENTIFICATION & DOCUMENTATION OF A MANUFACTURING CONTROL PLAN WHICH ADDRESSES:

QUALITY CONTROL
PROCESS CONTROL
MATERIAL TRACKING

IDENTIFICATION OF REQUIREMENTS FOR EACH CONTROL POINT:

SENSOR TYPE
CAUSE AND EFFECT RELATIONSHIP
FREQUENCY OF SAMPLING
CIM INTEGRATION REQUIREMENTS

DEVELOPMENT OF DEMONSTRATION CONTROL PLAN

- ☞ RETORT CIM INTEGRATION
- ☞ QUALITY CONTROL LAB
- ☞ SANITATION CONTROL
- ☞ MATERIAL TRACKING
- ☞ WEIGHT CONTROL
- ☞ MRE PACKAGING LINE INTEGRATION
- ☞ GRAVY PREPARATION CONTROL SYSTEM

INTEGRATION WITH STP#14 AND STP#16

Capital Requisition List

Retort CIM,	
hardware	$10,000
modification of software	$tbd
Quality Control Lab	
hardware	$20,600
software	$200
Sanitation Control	
hardware (partial)	$150
Material Tracking	
hardware (partial)	$11,600
software	$835
Weight Control	
hardware (partial)	$1,566
remaining incorporated in sub contract by STP#14	
MRE Packaging Line Integration	
sub contract by STP#16	
Gravy Preparation System	
sub contract by STP#14	
Total Estimated Cost	$44,951

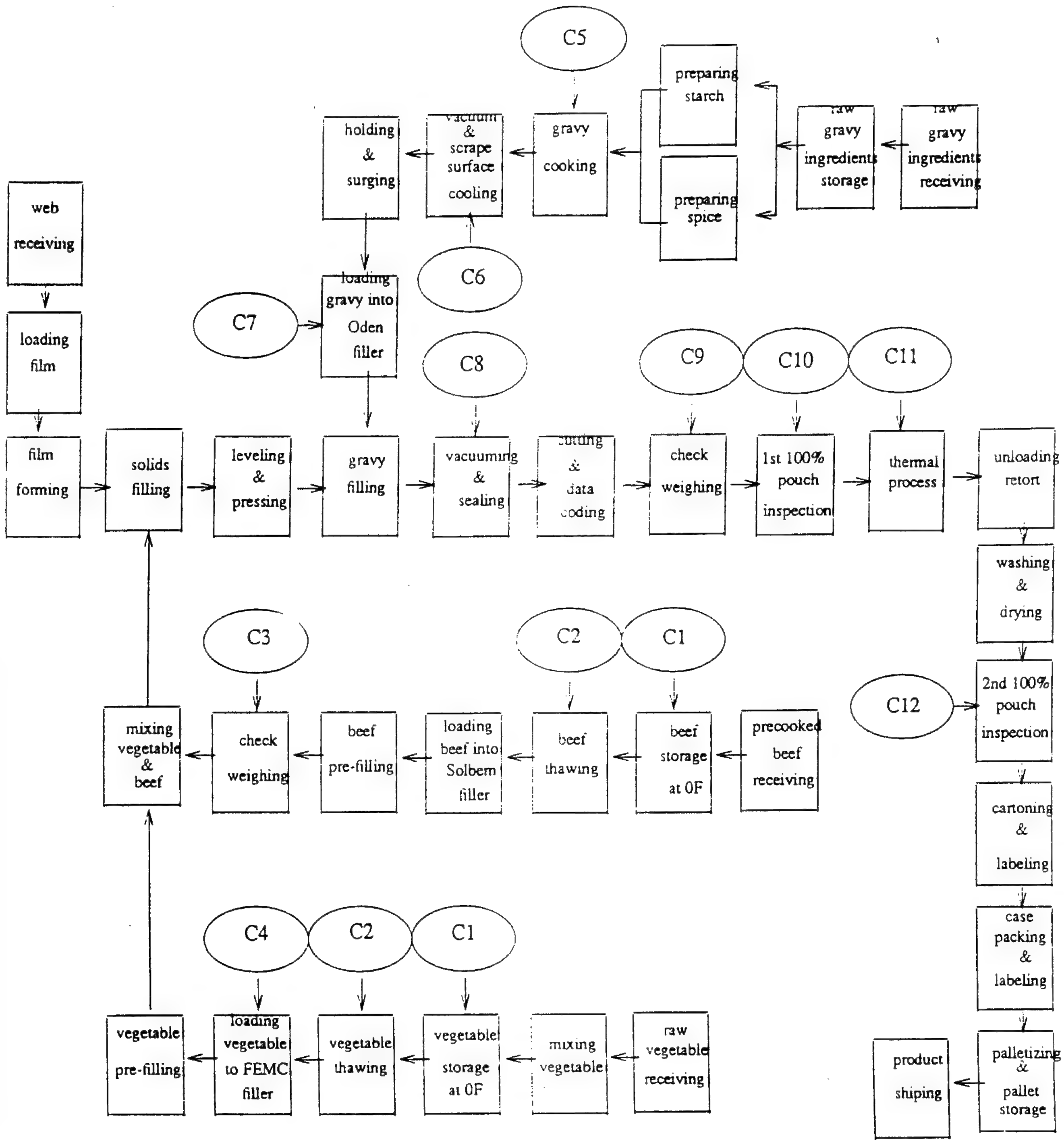


Figure 6: Process Control Points for MRE Line

Table 3: Descriptions of Process Control Points for MRE Pouch Line

Station C1
Beef/Vegetable Freezer Storage Control

	Control Variable	Q/R/H	Sensors	I/O	Controller	Manipulated Variable	Frequency	Monitor	DBase	Range	Accuracy
C1-1	Temperature	Q,H	Thermometer	e/m	local recorder	thermostat	once a day	chart	no	-20+20 F	+/- 2 F
C1-2	Temperature	Q,H	Thermometer	e/e	thermostat	Compressor on/off	continuous	none	no	-20+20 F	+/- 2 F
C1-3	Time being stored	Q,H	Bar Code Reader	e/-	PC#1	N/A	all item stor	inventory	yes	N/A	N/A

Station C2
Beef/Vegetable Thawing Control (Refrigerator)

	Control Variable	Q/R/H	Sensors	I/O	Controller	Manipulated Variable	Frequency	Monitor	DBase	Range	Accuracy
C2-1	Temperature	Q,H	Thermometer	e/m	local recorder	thermostat	once a day	chart	no	30-70 F	+/- 2 F
C2-2	Temperature	Q,H	Thermometer	e/e	thermostat	Compressor on/off	continuous	none	no	30-70 F	+/- 2 F
C2-3	Time of defrost	Q,H	Bar Code Reader	e/-	PC#1	N/A	every lot	inventory	yes	N/A	N/A

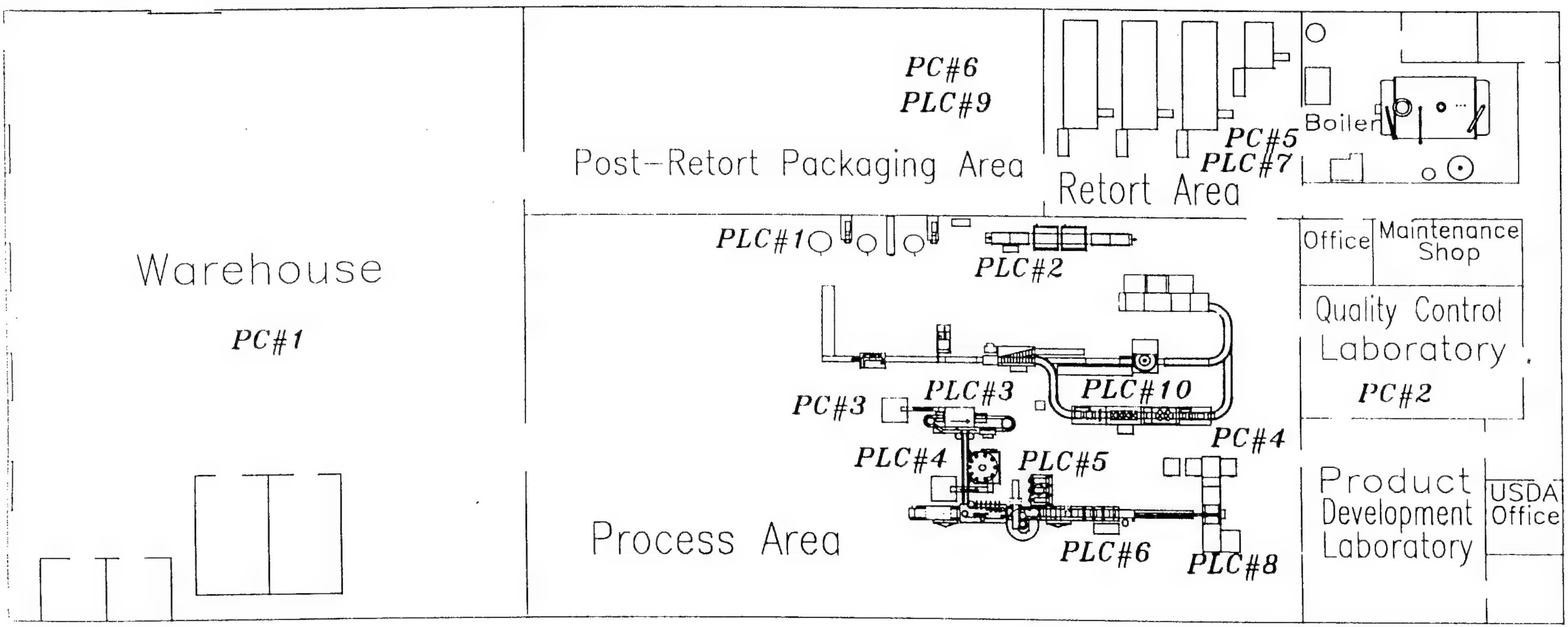
Station C3
Solbern Filler Control

	Control Variable	Q/R/H	Sensors	I/O	Controller	Manipulated Variable	Frequency	Monitor	DBase	Range	Accuracy
C3-1	Solid level	R,H	Level Sensor	e/e	PLC#3	load on/off	continuously	tbd	no	N/A	N/A
C3-2	Cup fill weight	R,H	Check weigher	e/e	PLC#3	reject yes/no	continuously	digital readou	no	N/A	N/A
C3-3	Beef dump weight	R,H	Scada node/check weigher	e/m	PC#3/SPC	Solbern filler setting	continuously	X & MR chart	yes	N/A	N/A
C3-4	Beef temperature	Q,H	Thermometer	m/m	PC#3/SPC	Thawing process	4 sample/hr	X-bar & R chart	yes	20-50 F	+/- 2 F
C3-5	Foreign odor	Q,H	Human	m/m	PC#3	1. stop line/hold prod	every hour	Checklist	yes	N/A	N/A
C3-6	Foreign color	Q,H	Human	m/m	PC#3	2. check raw material	every hour	Checklist	yes	N/A	N/A
C3-7	Foreign material	Q,H	Human	m/m	PC#3	3. check environment	every hour	Checklist	yes	N/A	N/A

Station C4
FEMC Filler Control

	Control Variable	Q/R/H	Sensors	I/O	Controller	Manipulated Variable	Frequency	Monitor	DBase	Range	Accuracy
C4-1	Solid level	R,H	Level Sensor	e/e	PLC#4	load on/off	continuously	tbd	no	12 "	+/- 2
C4-2	Vegetable dump weight	R,H	Scale	e/m	PC#3/SPC	FEMC filler setting	every 15 min.	X-bar & R chart	yes	50-150 gram	+/- 1
C4-3	Vegetable temperature	Q,H	Thermometer	m/m	PC#3/SPC	Thawing process	4 sample/hr	X-bar & R chart	yes	20-50 F	+/- 2 F
C4-4	Ratio of combination	R,Q	Scale	m/m	PC#2/SPC	Mixing process	4 sample/hr	X-bar & R chart	yes	1-50 g	+/- 1
C4-5	Foreign odor	Q,H	Human	m/m	PC#3	1. stop line/hold prod	every hour	Checklist	yes	N/A	N/A
C4-6	Foreign color	Q,H	Human	m/m	PC#3	2. check raw material	every hour	Checklist	yes	N/A	N/A
C4-7	Foreign material	Q,H	Human	m/m	PC#3	3. check environment	every hour	Checklist	yes	N/A	N/A

Figure 1: Food Manufacturing Technology Facility Layout



RETORT CIM INTEGRATION

OBJECTIVE:

DEVELOP AND IMPLEMENT A CIM BASED RETORT CONTROL AND DATA MANAGEMENT SYSTEM THAT MAXIMIZES THE USE OF SENSORS, DETECTORS AND DATA ENTRY STATIONS TO CONTROL, MEASURE, RECORD AND ANALYZE THE ESSENTIAL FUNCTIONS OF THE RETORT PROCESS IN ANY OF THE FOUR HEATING MODES

HARDWARE REQUIREMENTS	(~$45,000)
AB PLC SERIES 5	
OPERATOR INTERFACE PC	
IBM PC COMPATIBLE	(incl)
NOVEL NETWARE INTERFACF	(incl)
DATA HIGHWAY PLUS INTERFACE	(incl)
FILE SERVER	
NOVEL NETWARE	(stp#16)
RETORT PROGRAM DEVELOPMENT PC	
IBM PC COMPATIBLE	(existing)
NOVEL NETWARE INTERFACE	(stp#16)
RETORT	
MODULATING VALVES	(incl)
LEVEL SENSORS	(incl)
ELECTRONIC REFERENCE THERMOMETER	(donated)
SOFTWARE REQUIREMENTS	(incl with hardw)
LADDER LOGIC DIAGRAM FOR PLC	
RETORT PROGRAM DEVELOPMENT SOFTWARE	
OPERATOR/PROCESS INTERFACE SOFTWARE	
NOVELL NETWARE	

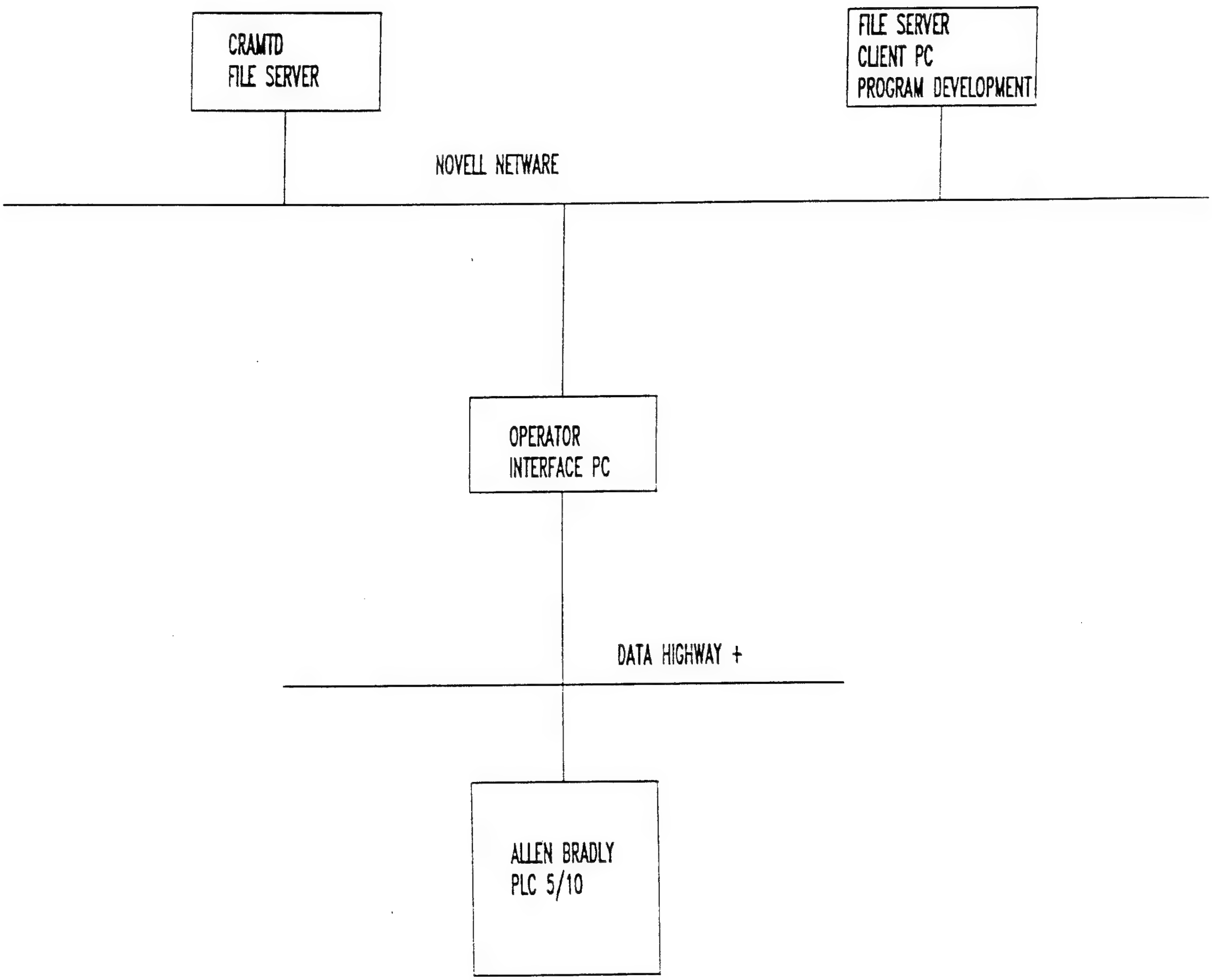
FEATURES:

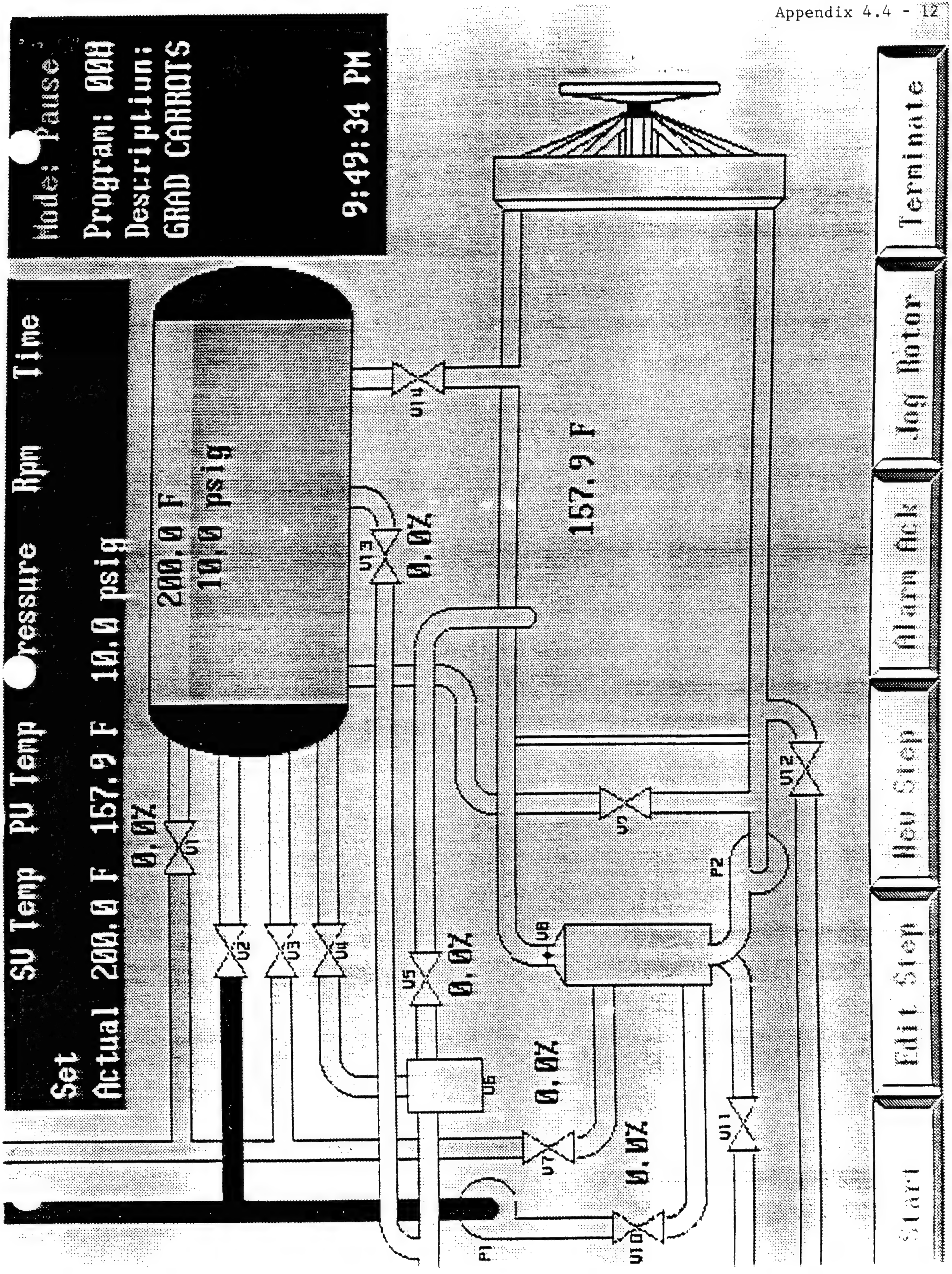
RETORT PROGRAM DEVELOPMENT
- DOS COMPATIBLE
- MENU DRIVEN
- STORAGE OF DEVELOPED PROGRAM IN FILE ON FILE SERVER

OPERATOR INTERFACE:
- DOS COMPATIBLE
- TOUCH SCREEN
- INTERACTIVE PROCESSING
- GRAPHICS DISPLAY OF PROCESS STATUS
- RETORT CRATE(S) LOGGING FOR MAT. TRACKING
- AUTOMATIC GENERATION COOK NUMBER
- OPERATIONAL INDEPENDENT FROM NETWORK
- PID AND ALARM LIMITS HEATING MODE AND PROCESS STEP SPECIFIC
- IMPROVED RAMP CONTROL FUNCTIONS FOR TEMPERATURE AND PRESSURE
- REPLACEMENT OF MANUAL READINGS AND CHART RECORDERS
- ELECTRONIC REFERENCE THERMOMETER
- ELECTRONIC "CHART" RECORDER
- PROCESS DEVIATION CONTROL
- PROCESS MONITORING INDEPENDENT FROM PROCESS CONTROL
- DATA ACQUISITION IN BINARY FILE FORMAT
- FILE FORMAT COMPATIBLE WITH ORACLE DATA LOADER
- SEPARATE FDA APPROVED EVENT RECORDING

ISSUES:
- DEVELOPMENT AND IMPLEMENTATION COST
- ORACLE DATA LOADER
- THIS IS NOT SOLVING THE CAPACITY ISSUE FOR RETORTING
- COST OF ONE 1100 MM, 4 CRATE, USED, RETORT WITH SAME CONTROL SYSTEM FOR SINGLE HEATING MODE IS APPROXIMATELY $120,000

RETORT CIM PROJECT

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GRAD CARROTS
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Actual
SU Temp
PU Temp
Pressure
Rpm
Time
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157.9 F
10.0 psig
200.0 F
10.0 psig
157.9 F
0.0%
0.0%
0.0%
0.0%
0.0%
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10
V11
V12
V13
V14
P1
P2
Start
Edit Step
New Step
Alarm Ack
Jog Motor
Terminate

COST/BENEFITS:

* IMPROVED CONTROL STRATEGIES, REDUCTION OF VARIATION AND OPTIMIZATION OF PROCESS AND REDUCTION OF OVER PROCESSING
* IMPLEMENTATION OF MATERIAL TRACKING STRATEGY TO ENSURE PROPER LABELING OF PRODUCTS DURING POST PROCESS PACKAGING
* REDUCTION OF LABOR IN PROCESS AREA (50%, fp 1/93)
* REDUCTION OF OPERATOR ERRORS
* EARLY DETERMINATION OF PROCESS CAPABILITY CHANGES
*IMPLEMENTATION OF CIM AND ENABLING TO CHECK ALL CRITICAL FACTORS AUTOMATIC BEFORE PRODUCTS ARE LABELED AND PACKED

QUALITY CONTROL LAB

OBJECTIVE:

ACQUIRE THE NECESSARY HARDWARE AND SOFTWARE FOR OPERATING A QUALITY CONTROL LAB WHICH USES ADVANCED SENSORS TO ENSURE THAT PRODUCTS PRODUCED IN THE CRAMTD PLANT ARE IN COMPLIANCE WITH THE SPECIFICATIONS

HARDWARE REQUIREMENTS:

IBM COMPATIBLE PC WITH NETWORK CARD	(stp16)
AUTOCLAVE	($4,800)
COLONY COUNTER	($582)
GOLDFISH FAT EXTRACTOR	($5,625)
INCUBATOR	($1,653)
INTERNAL PRESSURE APPARATUS	(stp#23)
MICROSCOPE	($1,940)
TENSILE STRENGTH ANALYZER	($6,000)

SOFTWARE REQUIREMENTS:

DOS/MICROSOFT WINDOWS	(stp#16)
NOVEL NETWARE	(stp#16)
ORACLE DATA ENTRY FORMS	(stp#16)
SAS STATISTICAL SOFTWARE	($200)

FEATURES:

(ADVANCED) SENSORS,
LABORATORIUM INFORMATION SYSTEM,
STATISTICAL SOFTWARE (SAS) TO ANALYZE PRODUCTION DATA

ISSUES:

NONE

COST/BENEFIT

* QUALITY CONTROL OF RAW MATERIALS AND IN-PROCESS MATERIALS IS ESSENTIAL TO PREVENT THE PRODUCTION OF OUT-OF SPEC MATERIALS.
* THE CIM APPROACH WITH ORACLE DATA BASE ALLOWS FOR VENDOR ANALYSIS, RAW MATERIAL PERFORMANCE, YIELDS ETC.

SANITATION CONTROL

OBJECTIVE:

DEVELOP AND DEMONSTRATE METHODOLOGY FOR RAPID TESTING PROCEDURES TO VERIFY SANITARY CONDITIONS OF THE PRODUCTION LINE, AND PROCESS WATER.

HARDWARE REQUIREMENTS

ATP BIOLUMINESCENCE METER	(lease)
CHLORINE METER	($150)

SOFTWARE REQUIREMENTS

NONE

FEATURES:

RAPID MICROBIAL (ATP) TEST, RESULTS WITHIN MINUTES

ISSUES:

ONLY ONE UNIT TESTED
NEGOTIATING LEASE FOR SECOND UNIT, RECOMMENDATION FOR UNIT EXPECTED AFTER 12 MONTH OF ADDITIONAL TESTING. WILL INCLUDE THE EVALUATION OF VARIOUS MEDIAS, SURFACE SAMPLES ETC.

COST/BENEFIT

RAPID MICROBIAL TESTING PROCEDURE ALLOWS ON-LINE TESTING OF LINE SANITATION, AND REDUCE THE CHANGE THAT PRODUCT IS PRODUCED ON A LINE WHICH IS NOT SANITARY AND HAS TO BE RECALLED.

MATERIAL TRACKING

OBJECTIVE:

ACQUIRE AND DEMONSTRATE A MATERIAL TRACKING SYSTEM THAT WILL FOLLOW THE PRODUCT FROM RAW MATERIAL WAREHOUSE TO FINISHED PRODUCT WAREHOUSE.

FEATURES:

BAR CODE PRINTING
BAR CODE READING
STRATEGIES FOR FOLLOWING PRODUCT THROUGH A BATCH/CONTINUOUS/BATCH PROCESS
COMPLETE PRODUCT TRACEABILITY
PRODUCT TRACKING OF QC SAMPLES

ISSUES:

NONE

Figure 1. Layout of the Food Factory

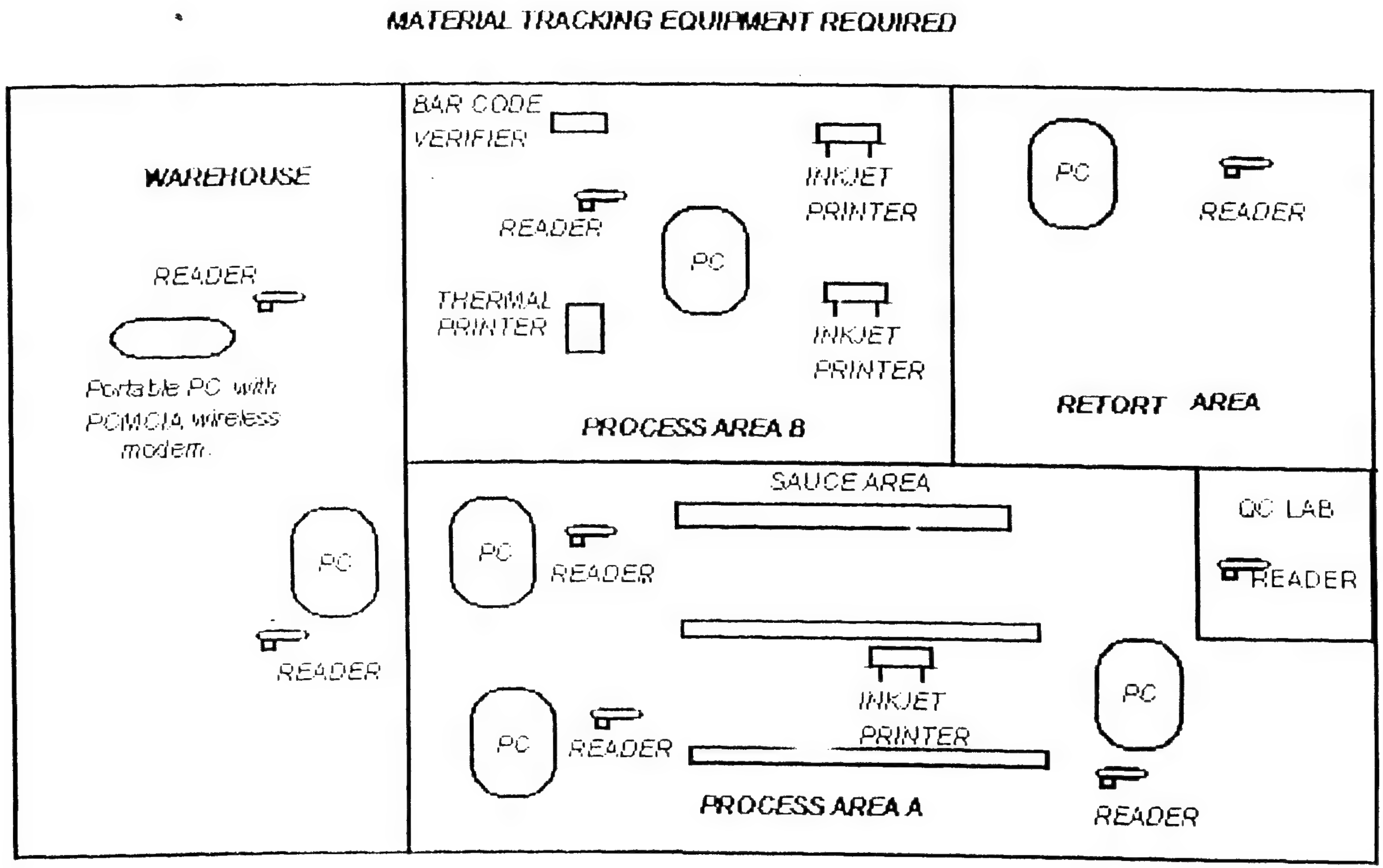
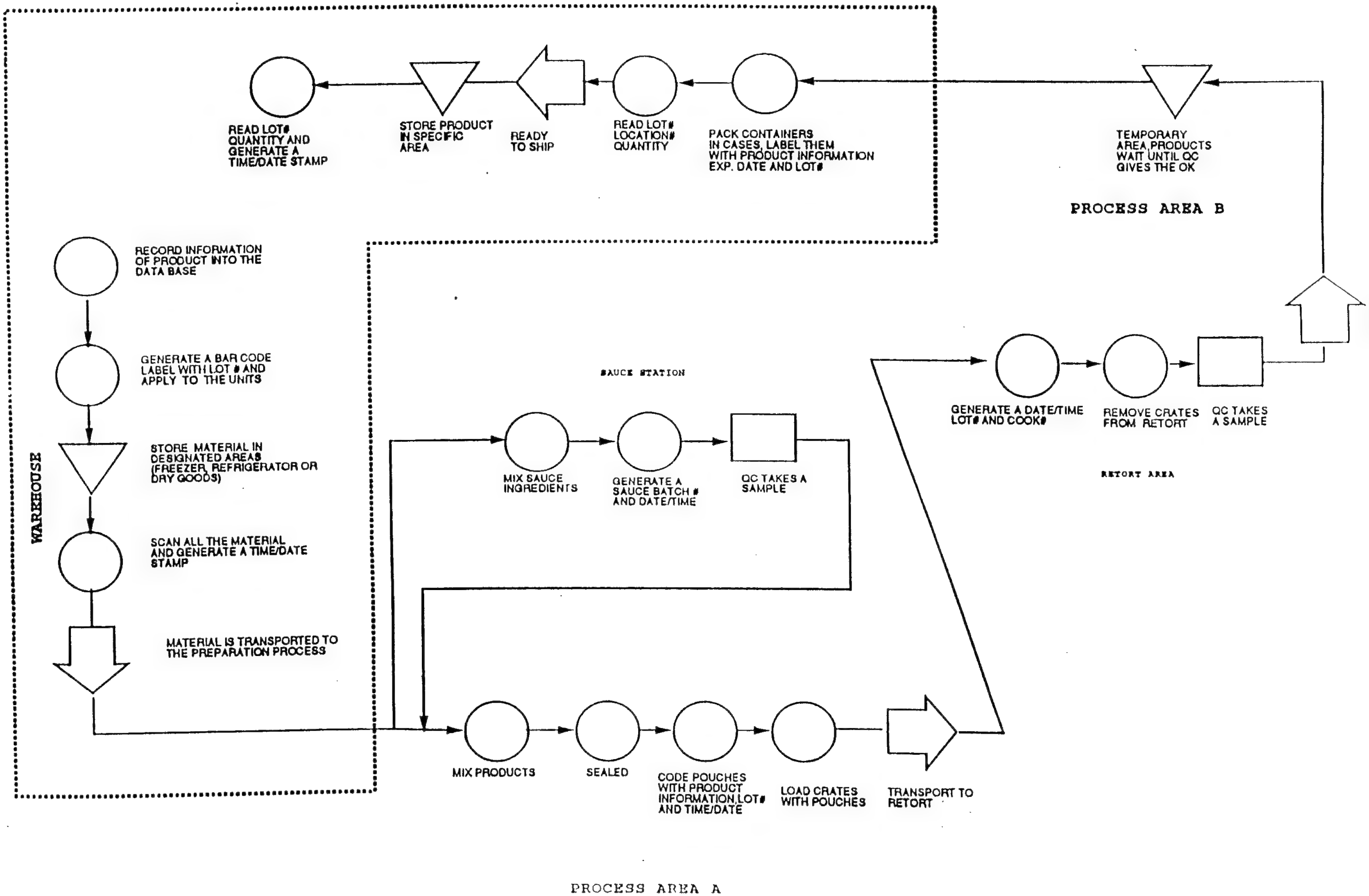


Figure 2. Material Flow

CRAMTD MATERIAL FLOW DIAGRAM



Benefits:

- Interactive Automatic Data Collection (ADC) systems are compatible with MIS requirements

  (database is not designed for batch mode)

- Reduction in data entry errors
- Material tracking from receipt to finished goods
- Reports can be easily generated
- Real time tracking of inventory
- Streamlined product recall procedures
- ADC systems are an integral component of an CIM system

Figure 4. Cost Summary

SUMMARY OF REQUIREMENTS FOR MATERIAL TRACKING

I. Bar Coding System

Quantity	Description	Approximate Cost
4	Visible Diode Hand-Held Scanners (approx. $1300 each)	$ 5,200
3	Small, hand-held readers (approx. $500 each)	1,500
1	Thermal Transfer Printers	1,700
1	Hand-Held Bar Code Verifier	1,300
1	Windows-Based Bar Code Labeling Software	835
???	Bar Code Labels	???
	Sub-total:	$10,535

II. Radio Frequency (RF) System

Quantity	Description	Approximate Cost
1	486, 25MHz "Portable" PC with PCMCIA wireless adapter card	$ 5,000
1	Hand-Held Laser Scanner	1,300
1	PCMCIA card for the host computer	1,000
	Sub-total:	$ 7,300

TOTAL ESTIMATE for Bar Coding and RF Systems:

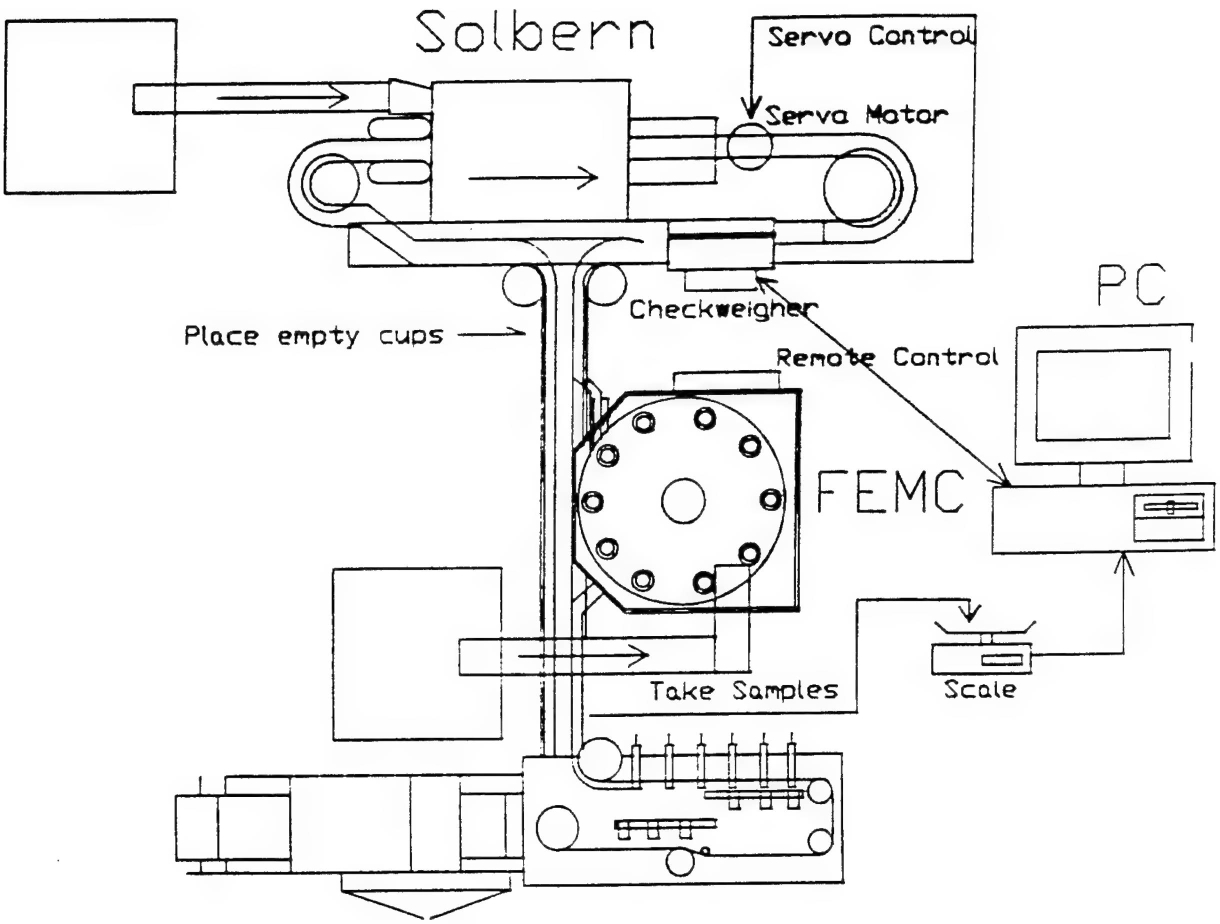
$17,835 plus costs for bar code labels and miscellaneous cables for peripheral devices

WEIGHT CONTROL

OBJECTIVE:

DEVELOP/DEMONSTRATE ADVANCED FEEDBACK CONTROL STRATEGIES, WHICH UTILIZES STATISTICAL TECHNIQUES TO ANALYZE AND CONTROL THE FILLING PROCESSES OF THE SOLBERN (ON-LINE) AND FEMC/ODEN/NET-WEIGHT (OFF-LINE)

Figure 1: Solbern and FEMC Fillers



SOLBERN CONTROL

HARDWARE REQUIREMENTS:

THREE ZONE CHECK WEIGHER	(stp#14)
REJECT/DIVERTER CONTROL	(stp#14)
SERVO FEEDBACK CONTROL MECHANISM	($6,000)
REMOTE PC	(stp#16)

SOFTWARE REQUIREMENTS:

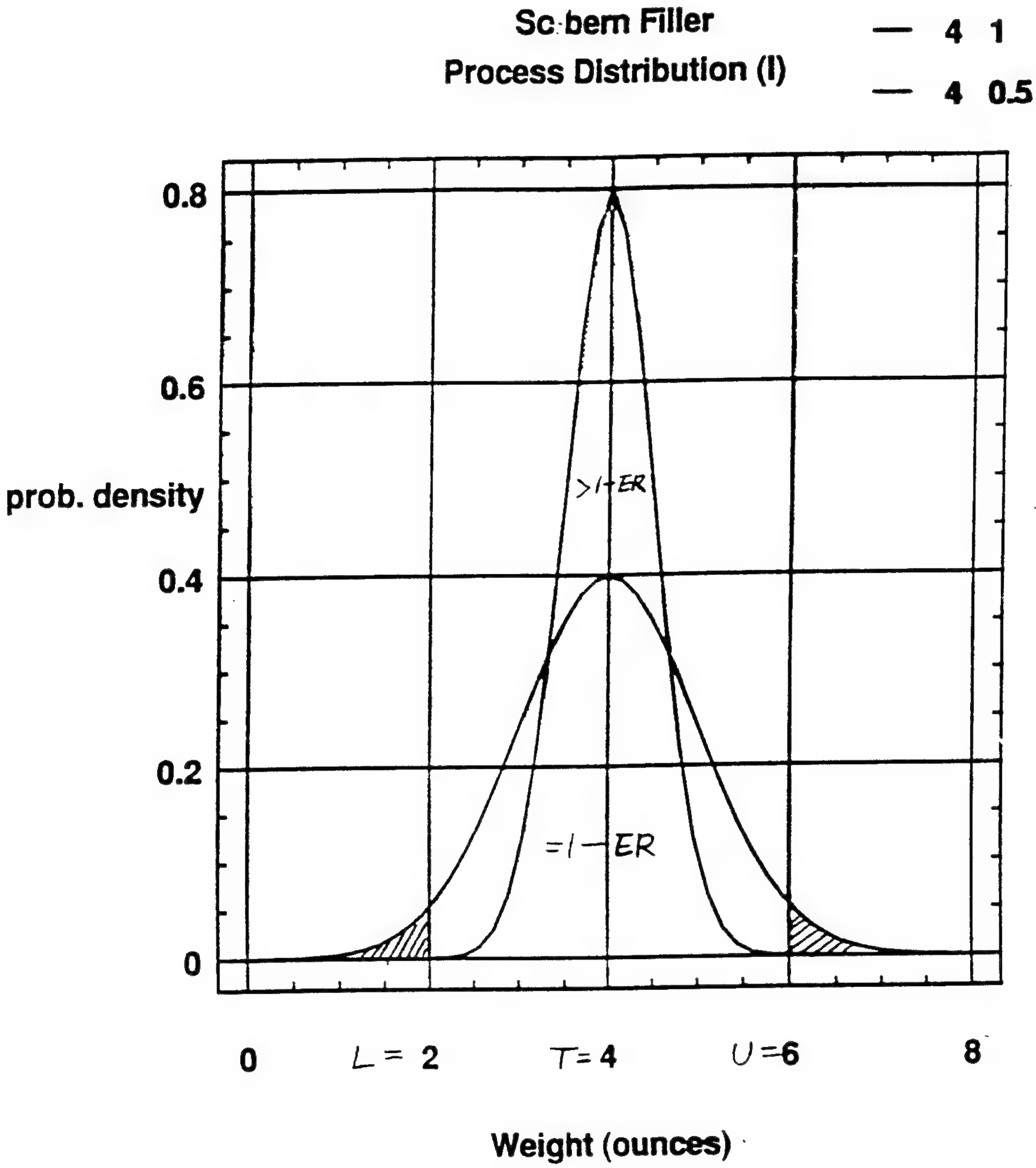
MULTIPLE PRODUCT SET-UPS	(stp#14)
STATISTICAL CAPABILITY (CHECKWEIGHER)	($1,200)
COMMUNICATION SOFTWARE WITH REMOTE PC	($1,500)
STATISTICAL SOFTWARE FOR REMOTE PC	($200)

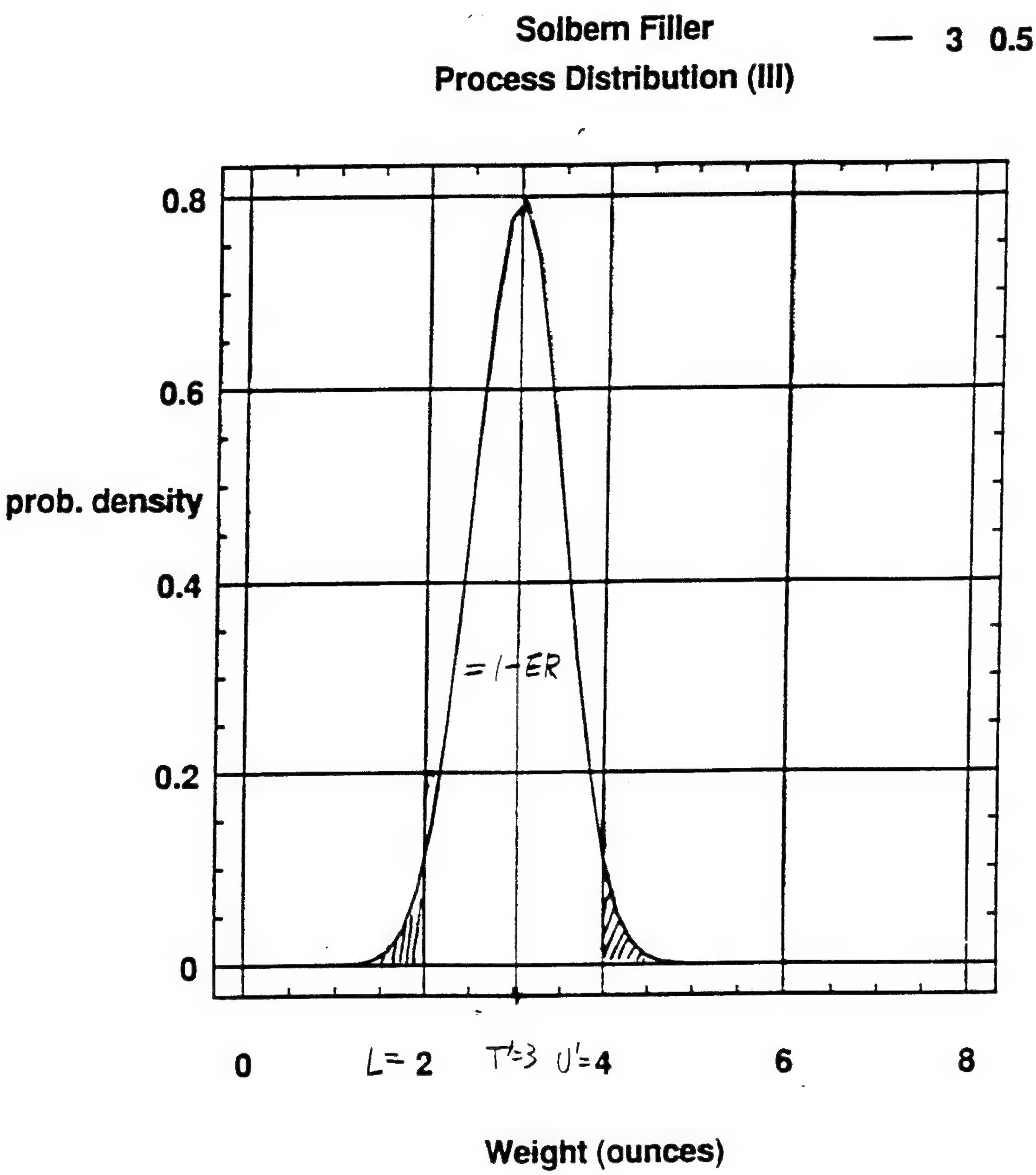
FEATURES:

REMOTE SET-UP CHECKWEIGHER
AUTOMATIC CALIBRATION (ZERO AND SPAN)
CONTROL OF AVERAGE WEIGHT (GOVERNMENT PRODUCTS)
CONTROL OF MINIMAL WEIGHT (CONSUMER PRODUCTS)
GIVE AWAY MINIMIZATION (CONSUMER TYPE PRODUCT)
~~MORE CONSISTENT QUALITY (FOR GOVERNMENT PRODUCTS)~~
ADJUSTMENT OF TARGET WEIGHT BASED ON PROCESS STATISTICS
ADJUSTMENT OF ZONE LIMITS TO MATCH PACKAGING LINE SPEED
LOCAL DISPLAY OF WEIGHT STATISTICS
REMOTE DISPLAY OF WEIGHT STATISTICS

ISSUES:

PROJECT PENDING APPROVAL OF STP#14 AND RECOMMENDATION TO SUB-CONTRACT THE REQUIRED HARDWARE
OVERALL CIM INTEGRATION PLAN OF THIS SYSTEM IN THE CRAMTD PLANT:
- COMMUNICATION
- CAN FIXDMAC/VIEW NODE BE USED OR DO WE NEED SEPARATE PC


Scbern Filler
Process Distribution (I)
— 4 1
— 4 0.5
0.8
0.6
prob. density
0.4
0.2
0
>1+ER
=1−ER
0
L = 2
T= 4
U =6
8
Weight (ounces)


Solbern Filler
Process Distribution (III)
— 3 0.5
prob. density
0.8
0.6
0.4
0.2
0
=1-ER
0
L= 2
T'=3
U'=4
6
8
Weight (ounces)

FEMC & ODEN & NET WEIGHT CONTROL

HARDWARE REQUIREMENTS:

BALANCE(S) WITH COMMUNICATION CAPABILITY	($1,300 each)
PC WITH COMMUNICATION CAPABILITY	(stp#16)
SCALE	
DATA BASE	
CALIBRATION WEIGHTS	($266)

SOFTWARE REQUIREMENTS:

COMMUNICATION SOFTWARE	(stp#16)
STATISTICAL SOFTWARE	(stp#16)

FEATURES:

ON-LINE DISPLAY OF CONTROL CHARTS
POSSIBLE FEED BACK CONTROL TO FEMC
AUTOMATIC ALARM SETTING BASED ON RUN RULES

ISSUES:

OVERALL CIM INTEGRATION PLAN OF THIS SYSTEM IN THE CRAMTD PLANT:
COMMUNICATION
CAN FIXDMAC/VIEW NODE BE USED OR DO WE NEED SEPARATE PC

COST/BENEFIT

STATISTICAL TECHNIQUES TO MINIMIZE GIVE AWAY FOR CONSUMER PRODUCTS
MORE CONSISTENT PRODUCT QUALITY
REDUCTION/ELIMINATION OF OUT OF SPEC PRODUCT
REDUCE IMPACT OF RAW MATERIAL VARIATION
REDUCTION OF THERMAL PROCESS CONDITIONS
STATISTICAL TECHNIQUES FOR MONITORING AND ALARMING OUT OF CONTROL PROCESS

MRE PACKAGING LINE INTEGRATION

OBJECTIVE:

DEVELOP INTEGRATED CONTROL SYSTEM FOR THE MRE LINE WHICH DEMONSTRATES COMPUTER INTEGRATED MANUFACTURING OF MRE PRODUCTS.

HARDWARE REQUIREMENTS: (~$50,000-$100,000)

SUPERVISOR PLC	(incl)
OPERATOR INTERFACE (FIXDMACS VIEW NODE)	(stp#16)
NOVELL NETWORK INTERFACE CARD	(stp#16)

SOFTWARE REQUIREMENTS:

LADDER LOGIC PROGRAM	(incl)
FIXDMACS	(stp#16)
VIEW NODE	(stp#16)
SAS	($200)

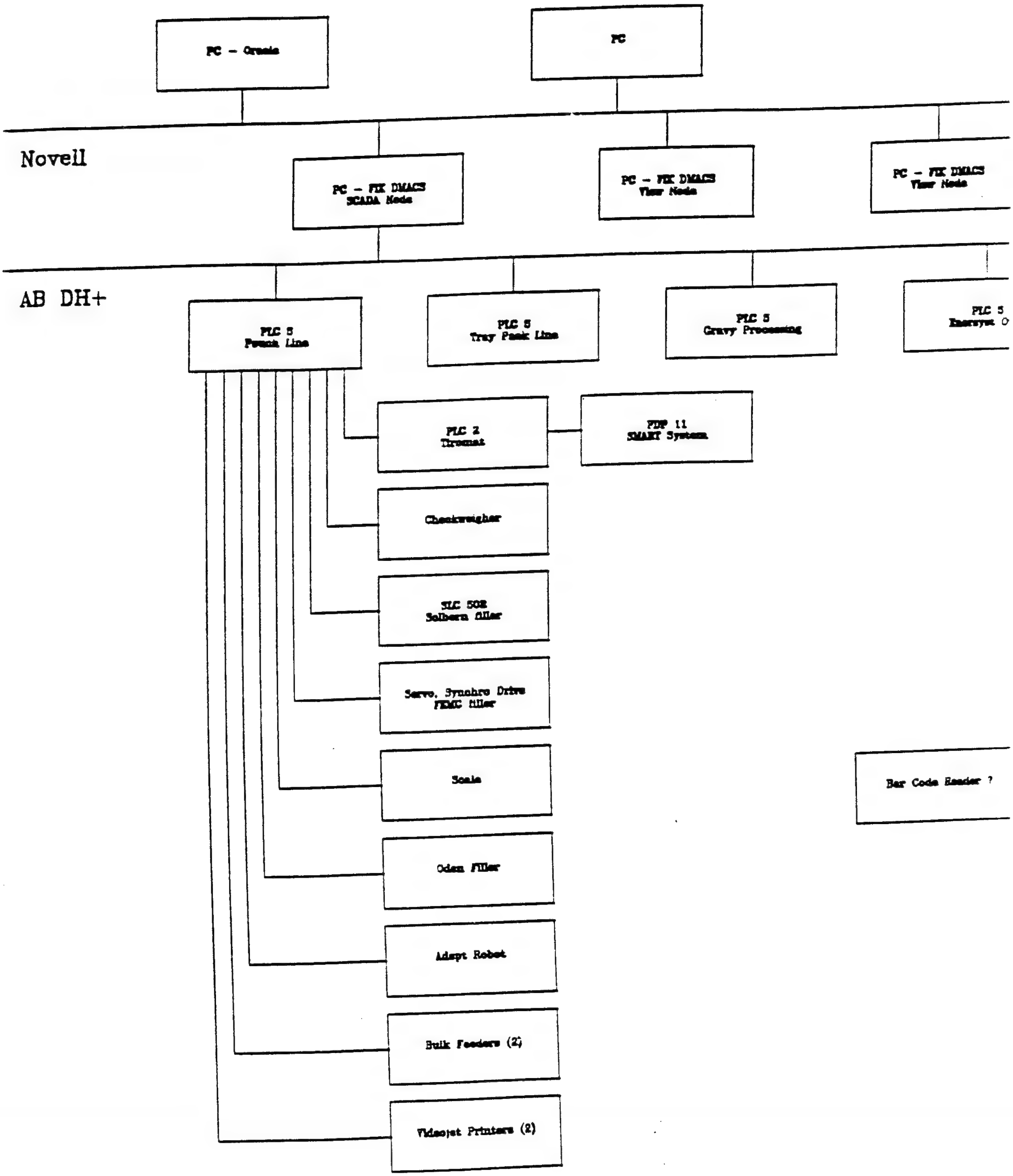
FEATURES:

REAL TIME GRAPHICAL DISPLAY OF ALL CRITICAL MRE PACKAGING DATA
DISPLAY ALARMS
DOWN TIME MONITORING
INTEGRATED WITH MATERIAL TRACKING
SAS CAPABILITY ON VIEW NODE (X-bar , MR chart)
PROCESS RECIPES COMING FROM DATA BASE TO SET-UP LINE
COMMUNICATION CAPABILITY WITH EACH UNIT OPERATION OF THIS PACKAGING LINE
STORAGE OF ESSENTIAL DATA FOR LATER ANALYSIS IN ORACLE DATA BASE

ISSUES:

COST OF INTEGRATION
IN-HOUSE VERSUS SUB-CONTRACT
WHICH STP SHOULD MANAGE THIS PROJECT #16

Integration of MRE Pouch Line



COST/BENEFIT:

DEMONSTRATION OF INTEGRATED MANUFACTURING PROCESS, WHERE THE PROCESS CAN BE MONITORED FROM ONE CONSOLE, POSSIBLE WITH MULTIPLE MONITORS FOR DISPLAY OF THE LINE STATUS, CONTROL CHARTS.
IMPROVED PROCESS CONTROL OF CRITICAL FACTORS

GRAVY PREPARATION CONTROL SYSTEM

OBJECTIVE:

DEVELOP CONTROL SYSTEM FOR GRAVY PREPARATION THAT DEMONSTRATES THE APPLICATIONS OF ADVANCED SENSORS AND COMPUTER SOFTWARE IN THE PROCESS CONTROL, QUALITY ASSURANCE AND MATERIAL TRACKING CONTROL FOR THE CRAMTD COMPUTER INTEGRATED MANUFACTURING SYSTEM

HARDWARE REQUIREMENTS:

COOK PROGRAM DEVELOPMENT INTERFACE PC	
IBM PC COMPATIBLE	(existing)
NOVELL NETWARE INTERFACE	(stp#16)
FILE SERVER	
NOVEL NETWARE	(stp#16)
OPERATOR INTERFACE PC	(tbd)
IBM PC COMPATIBLE	
NOVELL NETWARE INTERFACE	
DATA HIGHWAY PLUS INTERFACE	
PLC, AB SERIES 5	(tbd)

SOFTWARE REQUIREMENTS:

LADDER LOGIC DIAGRAM FOR PLC	(tbd)
RECIPE DEVELOPMENT SOFTWARE	(tbd)
OPERATOR INTERFACE SOFTWARE (FIXDMACS)	(tbd)
PREPARATION INTERFACE	
PROCESS CONTROL/MONITORING INTERFACE	
NOVEL NETWARE	(tbd)

FEATURES:

RECIPE SOFTWARE:
- MICROSOFT WINDOWS COMPATIBLE
- MENU DRIVEN
- STORAGE OF DEVELOPED RECIPE ON FILE SERVER

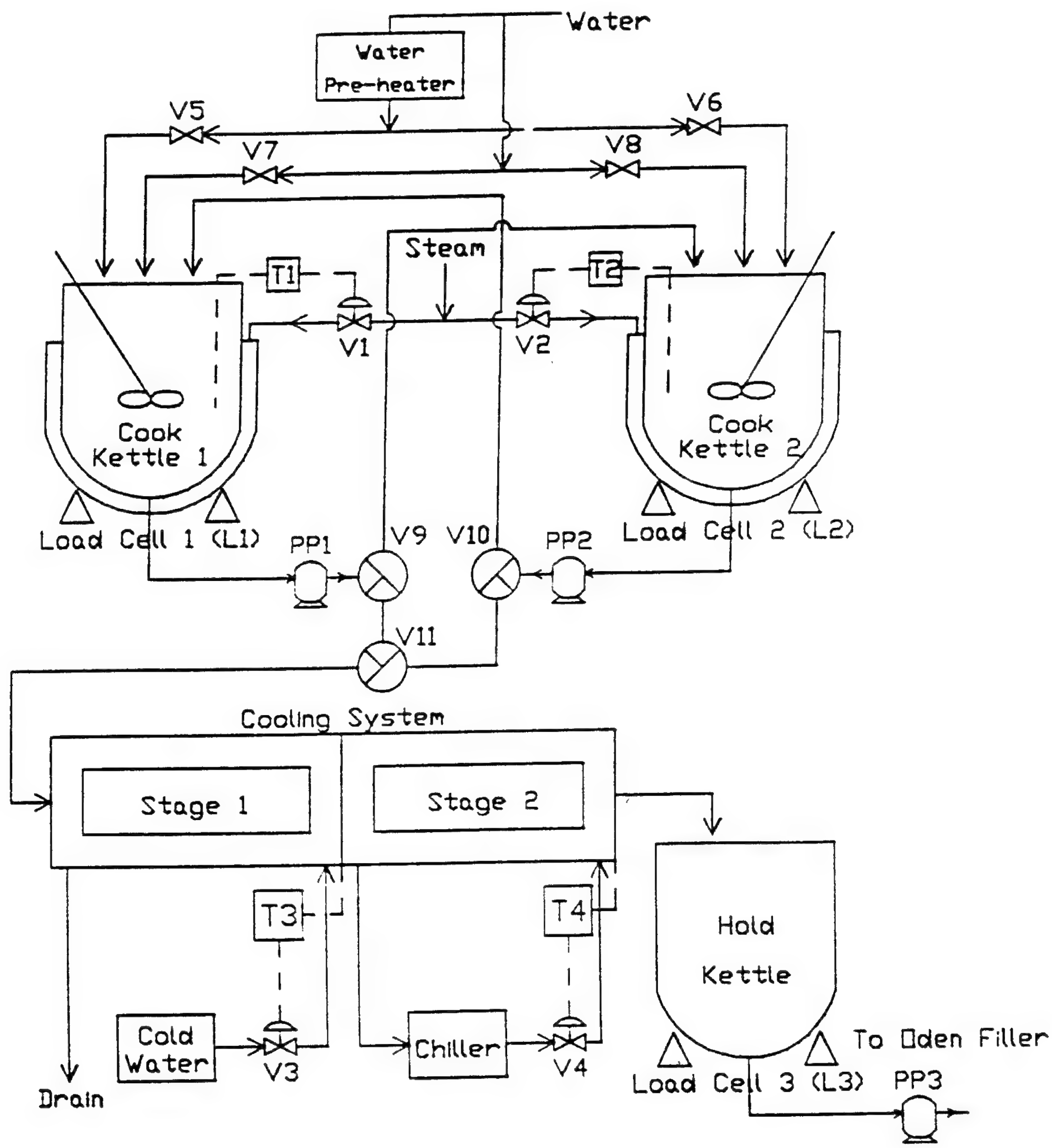
OPERATOR INTERFACE:
- MICROSOFT WINDOWS COMPATIBLE
- DOWN LOADING OF RECIPE FROM FILE SERVER
- INTERACTIVE MENU DRIVEN PRODUCT PREPARATION
- MATERIAL CODE SCANNING
- TEMPERATURE CONTROL CHARTS
- PROCESS STATUS SCREEN
- AUTOMATIC SEQUENCING OF PLC PROCESS PHASES
- AUTOMATIC ASSIGNMENT OF COOK BATCH #
- AUTOMATIC DATA COLLECTION AND STORAGE

PLC:
- PID TYPE CONTROL FOR TEMPERATURE
- ADAPTIVE CONTROL FOR TEMPERATURES
- LOAD CELLS TO MONITOR WEIGHT CHANGES
- DATA HIGHWAY PLUS
- AUTOMATIC SEQUENCING OF PLC PROCESS STEPS
- AUTOMATIC COMPENSATION OF MOISTURE LOSS

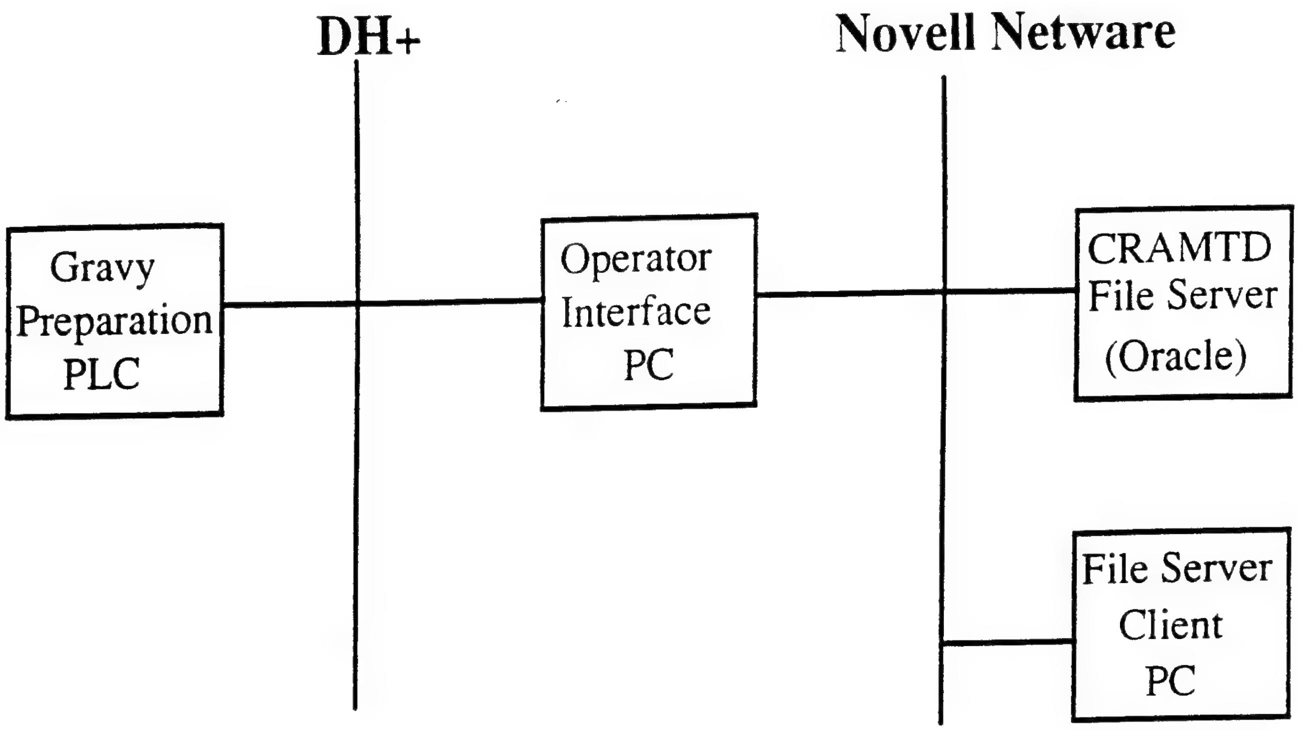
ISSUES:

* PROJECT PENDING APPROVAL OF STP#14 AND RECOMMENDATION TO SUB CONTRACT THE REQUIRED HARDWARE FOR GRAVY PREPARATION SYSTEM
* SHOULD A FIXDMACS-VIEW NODE BE USED AS THE OPERATOR INTERFACE
* STP#16 HAS TO DETERMINE HOW THE RECIPE/COOK PROGRAM IS TO BE STORED
* STP#16 HAS TO DETERMINE HOW THE PROCESS DATA IS GOING TO BE FILED IN ORACLE IF A NON FIXDMACS SYSTEM IS USED

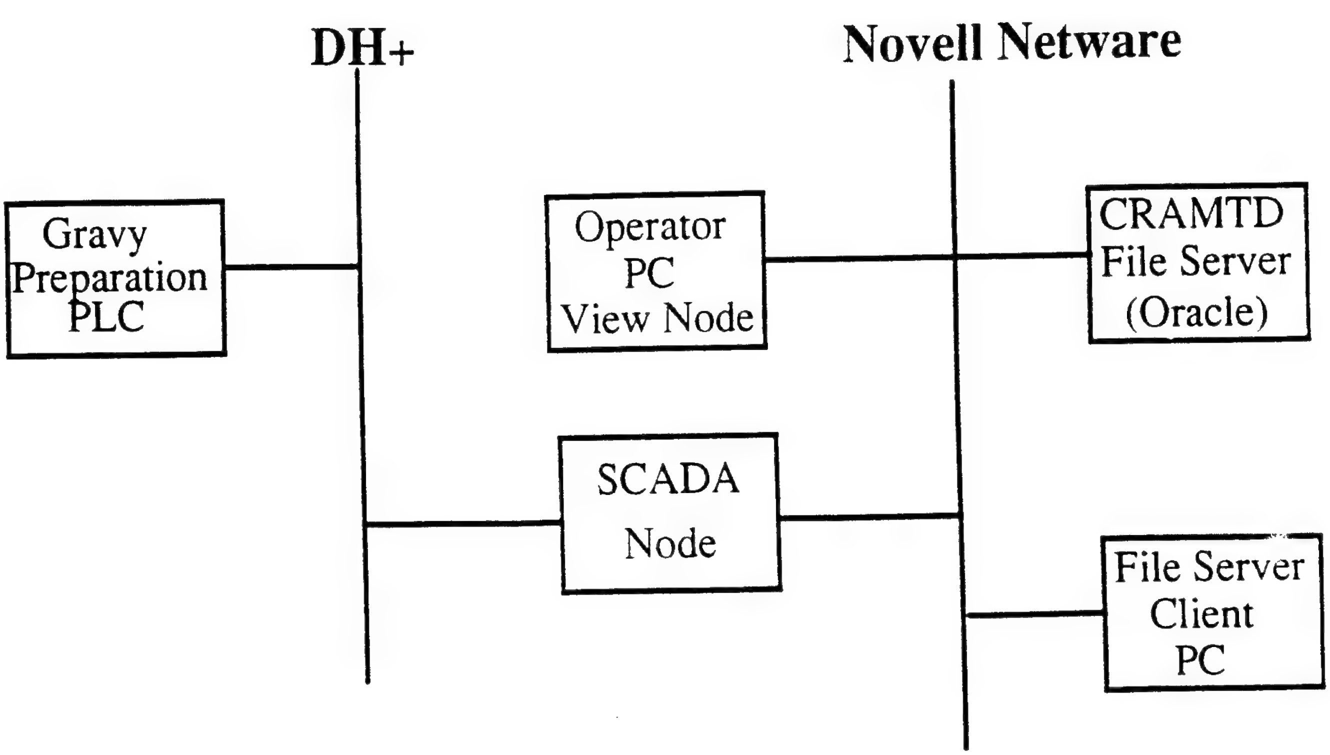
Figure 1: CRAMTD Gravy Preparation System



L1: Load cells for cook kettle 1
L2: Load cells for cook kettle 2
L3: Load cells for hold kettle
PP1: Positive displacement pump for cook kettle 1
PP2: Positive displacement pump for cook kettle 2
PP3: Positive displacement pump for hold kettle
T1: Temp. sensor for cook kettle 1
T2: Temp. sensor for cook kettle 2
T3: Temp. sensor for cooling stage 1
T4: Temp. sensor for cooling stage 2
V1: PID controlled steam valve for cook kettle 1
V2: PID controlled steam valve for cook kettle 2
V3: PID controlled cold water valve for cooling stage 1
V4: PID controlled coolant valve for cooling stage 2
V5: Pre-heated water supply valve for cook kettle 1
V6: Pre-heated water supply valve for cook kettle 2
V7: Cold water supply valve for cook kettle 1
V8: Cold water supply valve for cook kettle 2
V9: 3-way valve to direct liquid material from cook kettle 1
V10: 3-way valve to direct liquid material from cook kettle 2
V11: 3-way valve to direct gravy from kettle 1 or kettle 2 to cooling system



Alternative I



Alternative II

COST/BENEFIT:

FULLY INTEGRATED CIM APPROACH FOR PREPARING GRAVY
REDUCTION OF HUMAN ERRORS BY REDUNDANT MEASUREMENT/CONFIRMATION
ADVANCED PID CONTROL, RESULTING IN MINIMAL PRODUCT VARIATION
INCORPORATION OF MATERIAL TRACKING STRATEGY (REAL TIME)
FLEXIBILITY FOR PREPARING MULTIPLE PRODUCT RECIPES
AUTOMATIC RECORD KEEPING OF BATCH SHEETS

Final Technical Report (FTR) 25.0 - STP #12

Appendix 4.5

Proposed Integration of MRE Pouch Line for Demonstration Runs

The State University of New Jersey
RUTGERS
Cook College - Center for Advanced Food Technology
C' AMTD Program

Specifications
For

Control System for Horizontal Form-Fill-Seal Production Line

This specification covers the requirements for a control system that will be used for the CRAMTD program under STP #16 - Implementation of Integrated Manufacturing. This specification includes control panel. PLC, wiring to existing machinery, installation of sensors. and software requirements for the PLC that will be used to coordinate machines on the horizontal form-fill-seal pouch line, while gathering information for data logging. Hereafter, this controller will be referred to as the "production line controller". The machines and their production line layout that are included in this specification are shown in Figure 1.

This specification consists of the folllowing sections:

1. Performance requirements
2. Hardware requirements
3. Software requirements
4. Modes of Operation
5. Documentation requirements
6. General
7. Accceptance
8. Shipping and installation

1.0 Performance Requirements

1.1 Operational Duty. The equipment is to be capable of continuous operation in a typical food production environment. This equipment must operate in a typical wash down area and must withstand the use of non-caustic detergent, bleach and high pressure water cleaning. Cleaning time will be provided daily as required by regulartory agencies(i.e., FDA. USDA) or at least once per day.

1.2 Scan Time. The scan time of the production line controller shall be sufficient to handle all data logging functions and reporting functions to the scada node when the filler and checkweigher are operating at speeds up to 300 cups per minute and the form-fill-seal machine is operating at 110 pouches per minute. The relationship of the production line contoller to the scada node and higher levels is shown in Figure 3.

2.0 Hardware Requirements

2.1 The controller hardware shall be a series 5 Allen Bradley PLC with a 5/12 processor or higher, based on the scan time and memory requirements to perform the control and data logging functions as described in section 1.2 and 3.0.

2.2 The control panel shall be a stainless steel floor mounted Nema 4 panel of approximate specifications and layout as shown in Figure 2. Hereafter, this will be referred to as "the panel". It shall have a flange mount main disconnect switch. The following components shall be mounted on the panel.

2.2.1 Control Switches

Push button start/stop contacts for the entire line.

Remote / Local select switches for the following subsystems: Solbern filler, FEMC filler, product feed fillers, checkweigher, Tiromat form-fill-seal machine, Adept robot, Oden filler, Videojet printers, and retort loader.

Selector switches that indicate which combination of three fillers are being used: Solbern dumper, Oden filler, Adept robot.

Interface for entering digital data and obtaining digital readout for set speeds of the following subsystems: Solbern shaker, drum, filler belt, and dumper belt.

2.2.2 Information displays

Digital readout of set speeds in 2.2.1, above.

Tiromat pouch production rate.

Inspection station reject count.

Retort rack loader rate and count.

Lamp on top of control cabinet to indicate status of line: red (stopped), green (running).

Digital readout of the product temperature data being collected by on-line sensors.

2.2.3 Pilot Lights

Product Feeders(2) - Power On (Ready), E-stop, Low Product Level.

Tiromat - Power On (Ready), Running, E-stop, Fault.

Solbern - Power On (Ready), Cycle Start, Pause, E-stop, Product Low Level, Dumper Jam, Dumper Starved.

FEMC - Power On (Ready), Product Low Level, E-stop, Low Speed, High Speed, Back Up Sensor.

Adept Robot - Arm Power, Program Running, Conveyor Start (On), Conveyor Stop, E-stop.

Videojets - Power On (Ready), Head, Print.

Retort Loader - Power On (Ready), E-stop, Pouch jam, No Pouch, No Rack.

Oden - Power On (Ready), Hopper Level, E-stop, Nozzle Fault.

Checkweigher - Power On (Ready), Fault.

Line Air Pressure Alarm
Vacuum Pressure Alarm

2.2.4 Terminal Displays
SMART Workstation and monitor, provided by Rutgers.
Adept Robot Workstation with Monitor and Mouse, provided by Rutgers.
Operator Interface with functions as described in sections 2.2.1, 2.2.2 and 2.2.3. Options quoted separately as follows:
a) A CRT display indicating line status and faults.
b) A touch screen panel view with a graphic display of the line, incorporating functions described in section 2.2.1, 2.2.2 and 2.2.3. Multiple screen levels or windows should display details for each machine.
View Node Operator Interface Workstation and Monitor as specified in Appendix A.
Contractor will provide a NEMA 4 Keyboard. It would be desirable if one keyboard could be used for all workstation interfaces.

2.3 All electrical wiring, connections, control boxes and components shall conform to NEMA 4 standards. Quick disconnects are to be used at all movable machinery. Wiring and conduits are to be off the floor, with a minimum number of drops from the ceiling.

2.4 The terminal CPU's will be mounted within the panel (SMART PDP11, Adept, view node operator interface as specified in Appendix A. and the PLC). All terminals shall have access to their computer disk drives through water tight doors.

2.5 Sensors and bar code scanners for on-line data acquisition shall be provided and installed by the contractor as per items 3.1.1.2, 3.1.3.2, 3.1.5.1, 3.1.6.2, 3.1.11.

3.0 Software Requirements

3.1 The following specifications refer to control and data logging requirements for the equipment shown in Figure 1. This equipment includes the Solbern filler, a checkweigher, FEMC filler, two product feed fillers, Tiromat form-fill-seal machine, Oden filler, Adept robot, Brenton Retort pouch loader, and Videojet printer.

3.1.1 Solbern Filler. The Solbern filler is programmed and operated by an Allen Bradley SLC 500 controller, model 02. It provides open loop control of the cup conveyor, cup transfer system, and the rotating filler drum. The following control functions should be available from the shop floor controller.

3.1.1.1 Production Line Control

Start / Stop: The Solbern filler should be started and stopped from the production line control panel. A return signal should be provided by the Solbern controller to indicate it is running.
Remote / Local operation: A Remote / Local switch should be provided on the production line control panel so that the Solbern filler can be operated under local control of the Solbern controller. When operating under remote control, the Solbern controller start button is overridden by the Solbern start button on the production line control panel. All control functions currently adjustable at the Solbern controller will be adjustable by remote input in the remote mode.
Checkweigher Conveyor: This conveyor should be placed under the control of the production line controller. This conveyor should start when the Solbern starts. Provision should be made to regulate the variable speed drive of this conveyor. If there is a high rejection rate from the Solbern because cups are being recycled empty, it should be possible to regulate this drive to a slower speed.

3.1.1.2 Data Logging

Line Stoppages: The production line controller shall record the source of all line stoppages such that this data can be collected by the scada node.
Low Product Level: The production line controller shall record the existence of a low product level from a sensor in the Solbern filler. This condition shall be used to replenish product from the product feed filler attending the Solbern.
Temperature Sensor: The contractor shall install a non-contact temperature sensor for acquiring the temperature of beef in the Solbern filler. Provision for collecting the data will be made in the production line PLC.

3.1.2 Checkweigher. The Checkweigher weighs filled cups coming from the Solbern filler and either accepts the fill weight or diverts the cup back to the filler because its weight is out of spec. The checkweigher controller also controls a stepper / servo motor that makes adjustments to the cup fill volume to compensate for out-of-spec weights. When downstream jams occur, the checkweigher controller passes cups back to the Solbern filler without recording weights. The checkweigher controller has an RS232 interface. The following functions should be available from the shop floor controller.

3.1.2.1 Production Line Control

Target Weights and Cutoffs: The production line controller shall be capable of downloading operational control data to the checkweigher controller. A download cycle shall be initiated by a computer communicating with the production line controller over data highway plus. Hereafter, this computer will be referred to as the "SCADA node". A download cycle shall consist of writing data to a set of registers of the production line controller. Data is then transferred over the RS232 port to the checkweigher. The contractor shall specify an appropriate handshake between the SCADA node and the production line PLC so that an acknowledgement is returned to the SCADA node when the operation is complete.

3.1.2.2 Data Logging

Weights: The checkweigher controller can transmit weights either individually or, on request, in blocks of size n. These options can be set in software. The production line controller should be able to set this function to either individual or block transmission. The production line controller should provide a set of registers to collect weight data and a corresponding set of registers to collect the time at which the weight was recorded and a corresponding bits that indicate the accept / reject zone in which the cup falls. A counter should provide the number of the last register beyond the base address that has been logged with a weight. The SCADA node will access weights by first enabling a bit that prevents new data logging from the checkweigher. The counter reading will then be taken. Starting from the base address, data will be read up to the current count. The cycle will end by reseting the counter and disabling the bit that inhibits data logging. The production line controller should be able to resume data logging at the weight sequentially following the last weight collected. The data logging will resume at the base addresses.

Count: The PLC shall maintain separate registers with the current count of filled cups that have been processed and the current count of filled cups that have been rejected. The total of these two registers indicate the total cups filled.

3.1.3 FEMC Filler. The FEMC filler provides continuous volumetric filling. The filling speed is controlled by a Danfoss variable speed drive and the cup height is controlled by an Electrocraft servo motor.

3.1.3.1 Production Line Control

Start / Stop: The FEMC filler should be started and stopped from the production line control panel. A return signal should be provided by the FEMC filler to indicate it is running.
Remote / Local operation: A remote / local switch should be provided so that the FEMC filler can be operated under local control. When operating under remote control, the start button on the FEMC controller is overriden by the start button on the production line control panel.
Control of cup height: Under remote control, cup height should be specified from the production line control panel. Adjustments via Eloctrocraft servo drive should be possible based on vegetable fill weight data as described in section 3.1.3.2.

3.1.3.2 Data Logging

Product Level: When the product level in the FEMC hopper is low alarm, a bit should be set in the production line controller.
Fault Condition: The production line controller should record the various failure conditions of the FEMC filler, including the motor drive failure.

Vegetable fill weights: FEMC fill weights are sampled and weighed on an off-line scale. This data shall be collected by the PLC and used to adjust FEMC cup height via servo control as described in section 3.1.3.1.
Temperature Sensor: The contractor shall install a non-contact temperature sensor above the main hopper for acquiring the vegetable temperature. Provision for logging the data will be made in the production line PLC.
Level Sensor: The contractor shall install an ultrasonic range sensor mounted above the FEMC main hopper. Provision for collecting the data shall be made in the production line PLC.

3.1.4 Product Feed Fillers. There are two bulk product feed fillers. One is servicing the Solbern filler and one is servicing the FEMC filler. In each case, low level sensors on the Solbern and FEMC detect the need for more material. The product feed fillers respond to a low level signal by conveying material into the Solbern or FEMC until a high level sensor is reached. At that point the conveyor is turned off until the low level sensor is encountered. This is a closed loop distributed control system and does not need to be integrated into the production line controller.

3.1.4.1 Production Line Control

Start / Stop: The product feed fillers should be started and stopped from the production line control panel. A return signal should be provided by the feed fillers to indicate they are on line.

3.1.4.2 Data Logging

Low product level: When the hoppers of the product feed fillers are low, a bit should be set in the production line controller. This will, in turn, turn on the low product pilot light. When material is brought from inventory and the hopper is replenished, this bit will be reset.

3.1.5 Oden Filler. The Oden filler consists of three rotary positive displacement pumps controlled by a digital controller encoder. There is no communication capability. Motion is controlled by a digital encoder coupled to a DC servo drive.

3.1.5.1 Production Line Control

On / Off Signal: When the Oden Filler is on, a return signal should be provided to the production line PLC to indicate it is on.

3.1.5.2 Data Logging

Temperature Sensor: The contractor shall install a non-contact temperature sensor for acquiring the gravy temperature. Provision for logging the data will be made in the production line PLC.
Level Sensor: An ultrasonic range sensor has been installed on the Oden filler. Gravy level data shall be logged by the production line PLC.

3.1.6 Tiromat Form-Fill-Seal Machine. The Tiromat is an intermittent motion form-fill-seal machine with four stations: Forming, Filling, Sealing, and Punching. The machine is controlled by an Allen Bradley PLC 2/17 controller that is programmed over RS232 using a proprietary software, the SMART system software. Once programmed, the PLC maintains functions within the control parameter setpoints. Under the configuration of Figure 1, programming of machine parameters shall be possible either from the SMART system or from the operator view node.

3.1.6.1 Production Line Control

Start / Stop: The Tiromat should be started and stopped from the production line control panel. A return signal should be provided by the Tiromat to indicate it is running.
Remote / Local operation: a remote / local switch should be provided so that the Tiromat can be operated under local control. When operating under remote control, the start button on the Tiromat is overriden by the start button on the production line control panel.
Program configuration and command bits: All program configuration and command bits currently programmed on the Tiromat controller should be capable of being programmed from the production line controller. A corresponding set of registers should be configured in the production line controller along with a software switch to download those registers to the Tiromat controller. A return signal from the Tiromat controller should indicate a successful data transfer. Setting registers in the production line controller and enabling the software switch for downloading will be done from the operator view node in the control panel via the SCADA node on Data Highway plus. Registers of the Tiromat controller are given in Appendix B.

3.1.6.2 Data Logging

Status bits / diagnostic bits / word assignments: All status and diagnostic bits, as well as measured data stored as integer or floating point variables, that exist in the Tiromat controller, should be duplicated in the production line controller. This data should be passed to the production line controller with the same frequency as currently exists when reporting data to the SMART system, which is approximately 1 Hz.
Production rate: A moving average of the production rate shall be calculated and stored in the production line controller. This calculation will be done every cycle and will be based on the previous five cycles.
Differential seal pressure: Two pressure transducers will be installed in the tiromat seal chamber, one on each side of the pouch film. Provision shall be made in the production

line controller for mapping the sensor data from the Titomat controller during each operating cycle.
Seal plate temperature: Six temperature transducers will be installed on the seal plate of the Tiromat. Provision shall be made in the production line controller for mapping the sensor data from the Tiromat controller during each operating cycle.
Temperature Sensor: The contractor shall install a non-contact temperature sensor above the pouch just before the sealing operation.

3.1.7 Adept Pack-One Robot. The Adept robot, with drive and vision system, is controlled by a MC 68000 processor controller. RS 232 Serial ports are available for communication with the robot controller.

3.1.7.1 Production Line Control

Start / Stop: The robot subsystem should have start / stop control from the production line control panel. A return signal should be provided to indicate it is running.
Remote / Local Operation: A remote / local switch should be provided so that the robot subsystem can be operated under local control. When operating under remote control, the start button of the robot subsystem is overridden by the start button on the production line control panel.

3.1.7.2 Data Logging

Fault Conditions: All fault conditions should be sent to production line controller, where they are time stamped for data logging. Pilot light should go on when robot is the cause of error.

3.1.8 Videojet Printer. The Videojet printer has a serial communication port that allows a remote device to download text to be printed.

3.1.8.1 Production Control

Text transfer: The production line controller should be able to download text to be printed. Such text will be input to the production line controller from the control panel.
Remote operations: The operations of start, print, and head should be under the control of the production line controller.

3.1.8.2 Data Logging

Failure mode: Printer failure should be logged and time stamped. A pilot light should be provided to indicate printer failure.

3.1.9 Line Pressure and Vacuum

3.1.9.1 Production control

Pressure alarm settings: Provision should be made for mapping pressure and vacuum data from the Tiromat controller and setting alarm limits in the production line controller from the operator view node for line air pressure and line vacuum pressure.

3.1.9.2 Data Logging

Air supply pressure and vacuum supply pressure: Pressure transducers will be placed in the air supply line and the vacuum supply line. Provision shall be made in the production line controller to log the analog signals from these transducers. Alarm indicators are provided as in section 2.2.3.

3.1.10 Retort Rack Loader

3.1.10.1 Production Control

Start / Stop: The retort rack loader should be started and stopped from the production line controller. A return signal should be provided to indicate that it is running.

3.1.10.2 Data Logging

Fault conditions: The production line controller should record and time stamp fault conditions of the retort rack loader.
Counts: The production line controller should record the production counts for pouches loaded into the rack.
Cage Identification: The production line controller should take a bar code identification of the cage loaded into the retort rack and the time that the first pouch is loaded into the cage. The bar code scanner will be designed into the retort rack by Rutgers personnel.

Ancillary Equipment:

3.1.11 Radio Frequency Bar Code Transmitter / Receiver. For material tracking purposes, the production line controller should include a bar code scanner and radio frequency transmitter and receiver. Provision should be made in the controller for recording material lot numbers as material is loaded into filling equipment. Such information will be time stamped for tracking purposes.

3.1.12 Pouch Inspection Station. In order to track quality control problems, final pouch inspections will classify defects into 8 classes. Defective pouches will be inserted into a disposal chute based on defect type. Each chute will have a proximity sensor to record the passing of parts. The production line controller must keep count of the daily

counts passing each proximity sensor. The contractor shall make provision in the production line controller hardware and software for 8 digital inputs for this purpose.

4.0 Modes of Operation

This section contains a description of the required modes of operation of the control system. Each mode includes a description of the events or sequence of events that characterize that mode of operation.

4.1 Start Mode

Check all machinery powered and ready.
Product feeders on.
Transfer pump on.
Wait until product level OK: Solbern, FEMC, Oden.
Dumper belt on.
Checkweigher belt on.
Wait until FEMC has cups (low level sensor activated).
FEMC drive on.
Solbern cycle start.
Adept robot start.
Robot conveyor start.
Tiromat start.
Retort loader and inspection conveyor on.
Videojet head and printer on.

4.2 Stop Mode

Tiromat stop.
Wait until Tiromat cycle end.
Feeders stop.
FEMC drive stop.
Solbern cycle stop.
Checkweigher stop.
Adept robot pause at end of cycle.
Conveyors stop.
Retort rack loader stop.
Videojet head and print off.

4.3 Production Line Setup Mode

Check power to all equipment.
Load operating program parameters: Tiromat, Checkweigher, FEMC servo, Adept robot, Oden, Videojet printers.

4.4 Fault on Line Mode

Minor faults should be indicated on the control panel by change in color of the machine indicator.
Major faults should stop the line and be indicated on the control panel by change in color of the machine indicator. The following are major faults: a machine stops running, critical machine parameter out-of-tolerance per QC, filler out of product, dumper jam, retort loader jam.

4.5 Emergency Stop Mode
E-Stop all equipment: Tiromat, Solbern, FEMC, Adept robot, robot conveyor, Oden filler, product feeders, Transfer pump, retort rack loader, conveyors, checkweigher conveyor stop, Videojet head and print off.

4.6 Manual Operation Mode
Manual (local) operation of any machine can be selected at control panel. While machine is set to manual, the line can be run automatically; however, any machine faults except E- will not stop the line.

5.0 Documentation Requirements

5.1 Software documentation shall be provided as follows:
1. The ladder logic diagram for the shop floor controller program.
2. A structured function chart that shows the modular design of the program.

5.2 Electrical drawings. Schematics shall be provided for all electrical wiring.
5.3 Layout drawings for control panel will be provided.
5.4 The contractor will supply manuals of operating procedures for all supplied equipment.
5.5 Contractor shall provide a spare parts list.

6.0 General

6.1 Cost. The proposal is to include total cost F.O.B. Rutgers University, CRAMTD building, 120 New England Avenue, Piscataway, NJ. Cost of optional equipment, recommended spare parts and accessories should be quoted but clearly delineated from the base bid.

6.2 Delivery Schedule. The vendor will specify engineering design, fabrication, testing and delivery schedule.

6.3 Service. The vendor will provide service as needed to fulfill requirements of the warranty and these specifications.

6.4 Award. The criteria for selecting a proposal will be based on the evaluation of the CRAMTD staff:

Delivery
Engineering features
Cost
Service
Training and support

6.5 Exceptions. The vendor is to clearly identify any exceptions taken from these specifications.

6.6 Warranty. The vendor warranties the equipment performance specified herein for one year from the date of acceptance.

7.0 Acceptance

Acceptance test. The equipment will be subject to an acceptance test to determine whether performance requirements have been met. The equipment will be tested for all functions as described herein.

8.0 Shipping and Installation

8.1 The equipment will be shipped F.O.B., Rutgers University, CRAMTD building, 120 New England Avenue, Piscataway, NJ.

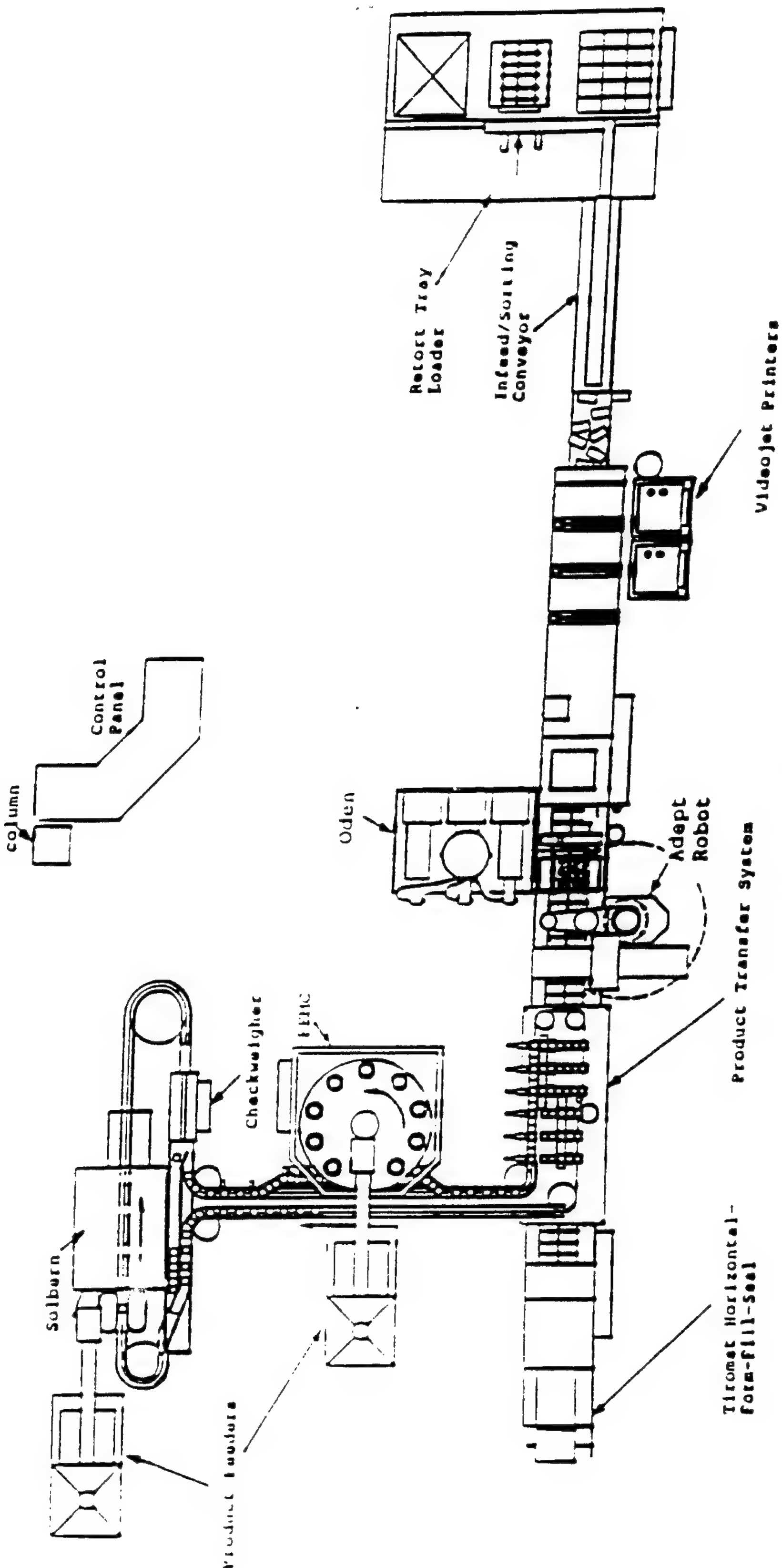
8.2 The vendor will assemble and install equipment in full working order and mprovide training to Rutgers Personnel in the operation and maintenance of the equipment.

APPENDIX A

Computer Hardware Specification for the MRE Pouch Operator Interface Workststion

- 80486 DX2 66MHZ Processor
- 16 mb RAM
- 350 mb Hard Drive
- 3.5", 1.4mb Floppy Drive
- (2) Serial, (1) parallel Port
- SVGA Graphics card with 1mb Memory
- 19" SVGA Monitor
- MS DOS, Version 6.x
- Microsoft Windows for Workgroups 3.11
- Ethernet Card: SMC Ethernet Plus Elite COMBO, 16 bit with 3 connectors:
  - AUI (thick ethernet, 10Base-5)
  - BNC (thin ethernet, 10Base-2)
  - RJ45 (twisted pair 10Base-T)

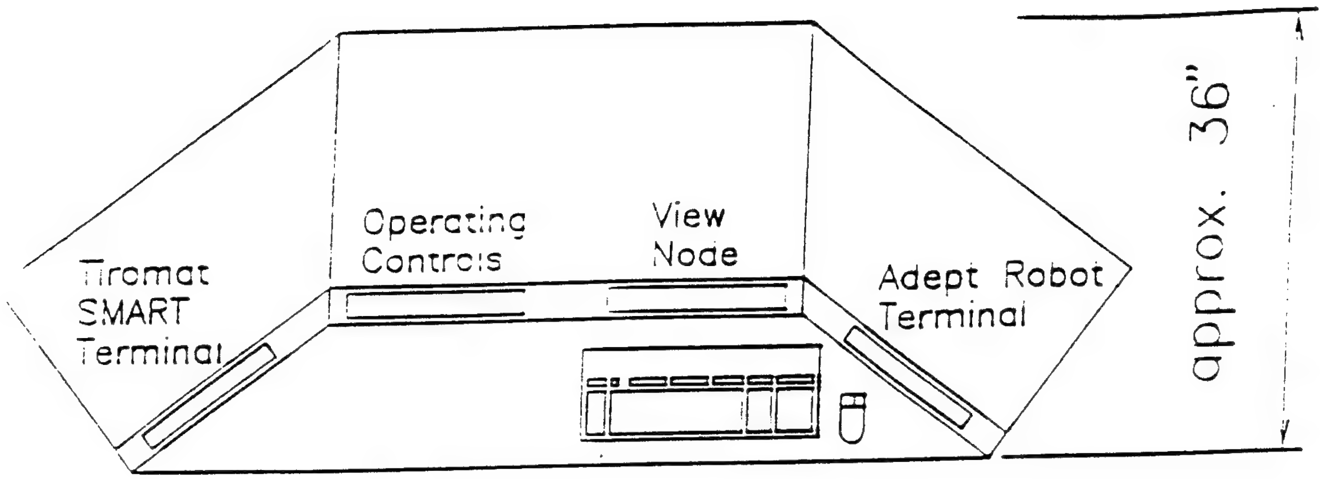
  Note: 3COM with same specifications also acceptable.
- Microsoft Mouse

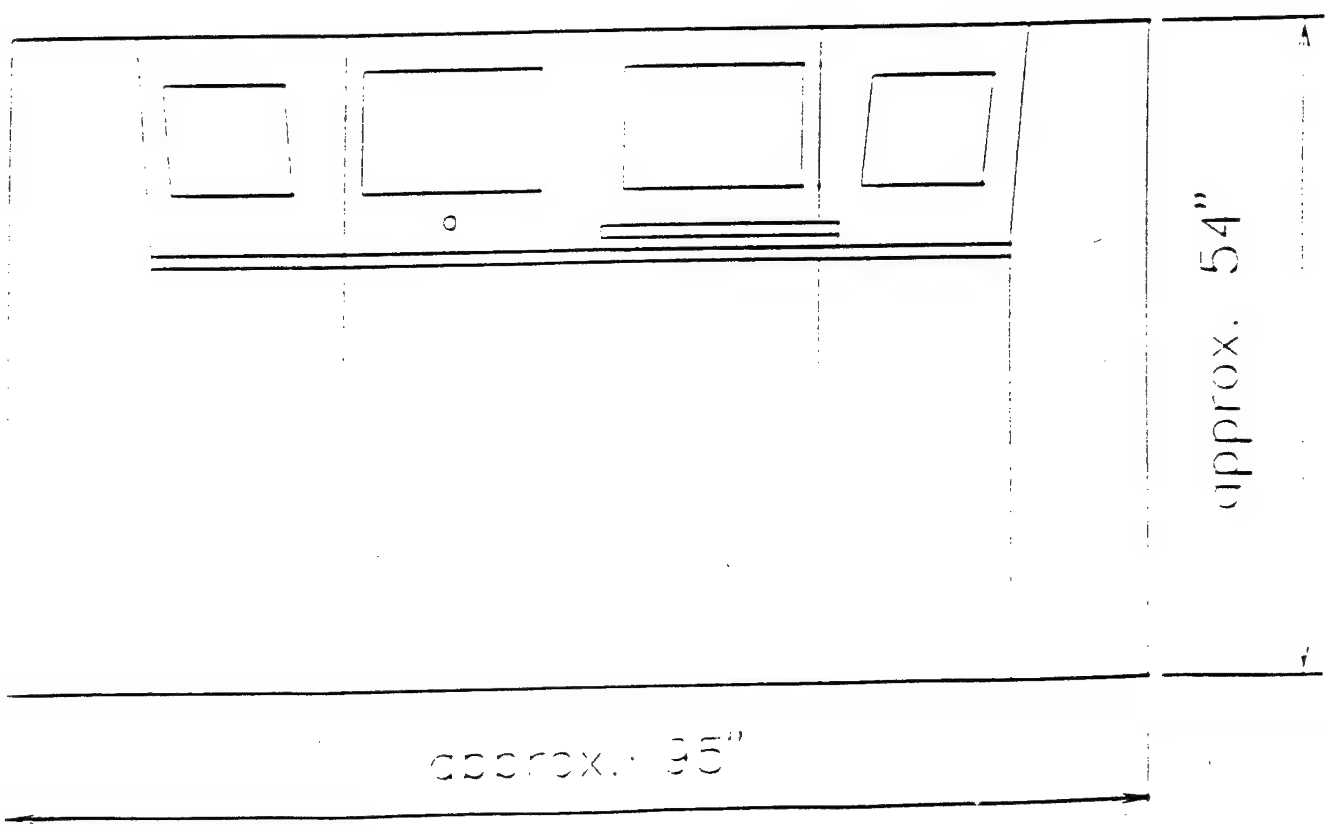


MRE POUCH LINE

FIGURE 1

Control Panel for H-F-F-S Line





Integration of MRE Pouch Line

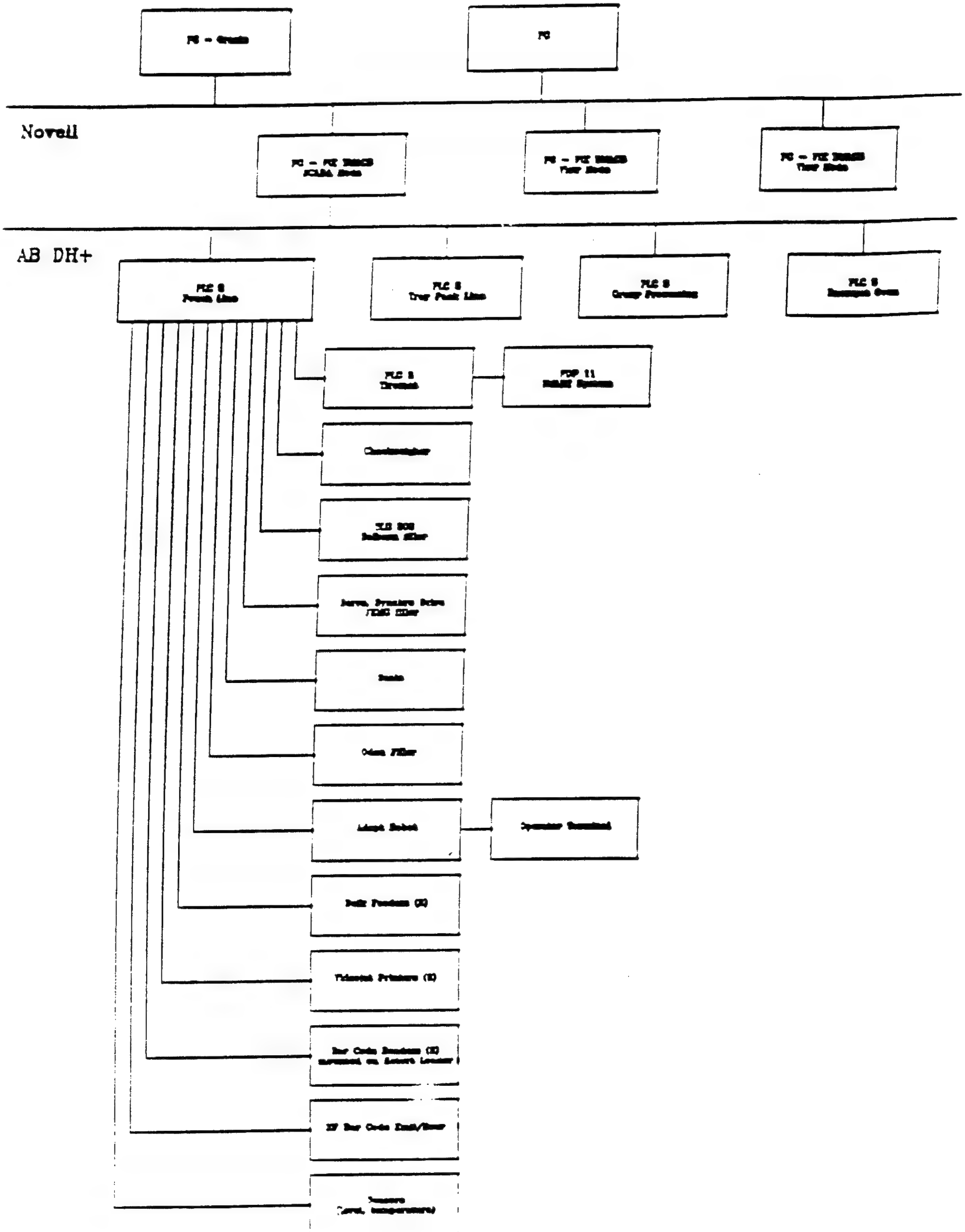


Figure 3

Food Mfg. Technology Facility
120 New England Avenue
BUSCH Campus
EXT. 5-6130

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

Interdepartmental Communication

Date: 6/27/94

To: Tom Boucher

From: Rieks Bruins

Re: Quality Control Tables for MRE Line Integration

Attached are quality control data points for production on the MRE packaging line. These quality control data points cover only the filling and packaging operation and not the preparation of the gravy and/or the preparation of the solids, such as vegetable pre-blending, meat defrosting, etc.

The tables are divided in three parts, each representing an area where the data is collected/measured. The first area is the filling system, the second is the packaging system and the third is the Lab. Quality control data is a combination of on-line and off-line data. Most data can be collected electronically, either continuously without operator assistance or based on a sampling plan and electronic data transfer at the request of the operator (examples are: weight data from FEMC, Oden and Net Weight). Other data has to be manually entered into the system via a form (examples: pouch preform size, operator comments). A distinction should be made to the location were the data is collected and how it should be entered into the system. First we have data that can be collected by the line operator and should be entered via the View Node, which is located in the new control panel. Other data is generated in the Lab, such as residual gas, seal strength, etc. The best place to enter this data into the system is via the QC Lab computer, either via an Oracle form or via View Node. Data generated in the QC lab is typically more complex and requires time to generate and is therefore not real time. Therefore, while entering data in the QC lab a sampling time stamp should be entered into the system, linking the results to a specific production time.

Identified in the tables for quality control points are also information regarding the display of the data for interpretation and the format of the data that should be used to store a subset of this data in the Oracle data base for permanent record keeping. Please give me a call if you have any questions regarding these tables.

c.c.
John Coburn
Ibrahim Laham
Argon Chen

QC Data Tiromat and Filling Systems

Date:_________
Operator:__________
Product Name:___________
Formula Number:____________
Product Lot Number______________

@ Filling System	FIXDMAC	ORACLE
Solbern Material Lot Number	Time Change Over to New Lot	
Solbern Product Temperature	X & MR chart	est mean &std/crate
Fill Weight @ Solbern	digital readout	est mean &std/crate
Accepted Fill Weight to Tiromat	X & MR chart	est mean &std/crate
% Under weight cups	digital readout	% under/crate
% Over weight cups	digital readout	% over/crate
% Total cups rejected	digital readout	% reject/crate
Cup Depth	digital readout	
FEMC Material Lot Number	Time Change Over to New Lot	
FEMC Product Temp.	X & MR chart	est mean &std/crate
FEMC Fill Weight	X-bar & R chart	{avg,range}/test
FEMC Fill Plate Position	digital readout	
ODEN Liquid Lot Number	Change Over Time to New Lot	
ODEN Liquid Temperature	X & MR chart	est mean &std/crate
Oden Fill Weight (Nozzle #1)	X-bar & R chart	{avg,range}/test
Oden Fill Weight (Nozzle #2)	X-bar & R chart	{avg,range}/test
Oden Fill Weight (Nozzle #3)	X-bar & R chart	{avg,range}/test
Oden Fill Weight (Nozzle #4)	X-bar & R chart	{avg,range}/test
Oden Fill Weight (Nozzle #5)	X-bar & R chart	{avg,range}/test
Oden Fill Weight (Nozzle #6)	X-bar & R chart	{avg,range}/test
Adept Robot Product Lot Number	Change Over Time to New Lot	
Adept Product Temperature	X & MR Chart	est mean &std/crate

Adept Product Fill Weight	X-bar & R chart	{avg,range}/test
Adept Product Thickness	X-bar & R chart	{avg,range}/test
Comments (Foreign Odor/Color/Material/Etc)	Whenever entered with time stamp	
@ Packaging System	**FIXDMAC**	**ORACLE**
Tiromat Line Speed	digital display	
Bottom Web Lot Number	Change Over Time to New Lot	
Top Web Lot Number	Change Over Time to New Lot	
Pouch Preform Size	X-bar & R chart	{avg, range}/test
Forming Pressure	digital display	
Air Supply Pressure	digital display	
Vacuum Supply Pressure	digital display	
Maximum Vacuum	X&MR Chart	est mean & std/crate
Vacuum Time	digital display	
Sealing Time	digital display	
Sealing Temperature (controller)	digital display	avg, min, max/crate
Seal Plate Temp Loc #1,2,3,4,5,6	digital display	avg, min, max/crate
Sealing Pressure	digital display	avg, min, max/crate
Defect # 1, seal wrinkles	total for lot	% per crate
Defect # 2, abrasion	total for lot	% per crate
Defect # 3, delamination	total for lot	% per crate
Defect # 4, tears/cuts	total for lot	% per crate
Defect # 5, leakers	total for lot	% per crate
Defect # 6, inadequate seal width	total for lot	% per crate
Defect #7, Other	total for lot	% per crate
Net Weight	X-bar & R chart	{avg,range}/test
Retort Crate Number	digital display	Crate #
Crate start fill time	Change Over Time to New Crate	

Pouches/crate		Quantity/crate
Comments: (Reason for Line Stop, etc)	Whenever entered with time stamp	
@ QC Lab	**Local Display**	**ORACLE**
Product Blend Ratio (4 samples/test)	X-bar & R Chart	{avg,range}/test
Liquid Viscosity (1 sample/liquid batch)	X & MR Chart	result
Residual Gas (4 pouches/test)	X-bar & R Chart	{avg,range}/test
Internal Pressure (4 pouches/test)	X-bar & R Chart	{avg,range}/test
Seal Width (4 pouches/test)	P Chart	{# defectives}/test
Seal Strength (4 pouches/test)	X-bar & R Chart	{avg,range}/test
Comments	Whenever entered with time stamp	